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Special Technical Report 12

SURVEY OF LITERATURE PERTAINING TO THE EQUATORIAL IONOSPHERE AND TROPICAL COMMUNICATION

By: GEORGE H. HAGN KENNETH A. POSEY

Prepared for:

U.S. ARMY ELECTRONICS LABORATORIES
FORT MONMOUTH, NEW JERSEY

CONTRACT DA 36-039 AMC-00040(E)
ORDER NO. 5384-PM-63-91

STANFORD RESEARCH INSTITUTE

MENLO PARK, CALIFORNIA

SRI

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By: GEORGE H. HAGN KENNETH A. POSEY

SRI Project 4240

Approved: W. R. VINCENT, MANAGER
COMMUNICATION LABORATORY

D. R. SCHEUCH, EXECUTIVE DIRECTOR
ELECTRONICS AND RADIO SCIENCES

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ABSTRACT

A survey of the literature pertaining to the equatorial ionosphere tropical radio communications, and related subjects is presented in bibliographical form. Authors' abstracts have been included whenever possible. The survey is intended to cover the period from the late 1920's and early 1930's through the early 1960's.

CONTENTS

PREFACE

This work was undertaken at Stanford Research Institute, Menlo Park, California as part of Contract DA-36-039-AMC-00040(E) to provide support for the MRDC Electronics Laboratory, a communications research and support laboratory operated in Bangkok, Thailand. The MRDC Electronics Laboratory is part of the Military Research and Development Center, a joint Thai-United States effort of the Thai Ministry of Defense and the U.S. Department of Defense (Project AGILE). The SRI work is sponsored by the Advanced Research Projects Agency (ARPA Order 371) and is being administered by the U.S. Army Electronics Command, Fort Monmouth, New Jersey.

The equatorial ionosphere requires special consideration. This bibliography attempts to catalog the published works on the vagaries of the geomagnetic equatorial ionosphere. Other subjects of interest to workers on the problem of communications in tropical areas have been selected for inclusion. The following sources have been examined:

1. Technical Journals and Magazines
    a. IEEE Proceedings
    b. IEEE Transactions on Antennas and Propagation
    c. IEEE Transactions on Communication and Electronics (formerly Communication Systems)
    d. IEEE Convention Records
    e. NBS Journal of Research, Part D
    f. Journal of Geophysical Research
    g. Journal of Atmospheric and Terrestrial Physics
    h. Journal of the Institution of Electrical Engineers, Part III (British)

The report list is probably the least complete, and we would appreciate notification of any omissions (especially reports) from recipients of this bibliography. We hope that you will find this survey both convenient and helpful, and would appreciate any comments as to organization, ease of use, etc., that you would like to make.

Menlo Park, California
February 1966

George H. Hagn
Kenneth A. Posey

NOTE TO THE READER

The material is arranged alphabetically by the first author's name and chronologically under each author. The initial letter of the first author's last name appears in the upper right-hand corner. A list of authors is given at the end of the report. A comprehensive subject index is in preparation and will appear as a separate volume.

Unless otherwise stated, sources of abstracts are referenced after the abstract, according to the following key:

A	Author's abstract or author approved
DDC	Defense Documentation Center [Formerly Armed Services Technical Information Agency (ASTIA)] AD numbers have been included when possible.
B	A.K. Brown's "Abstracts of Articles on Ground Backscatter Propagated by the Ionosphere"
C	Written by a member of the Communication Laboratory, Stanford Research Institute
EEA	Science Abstracts: Section B, Electrical Engineering Abstracts
M	L. A. Manning's Literature of the Ionosphere
N	W. Nupen's "Bibliography on Ionospheric Propagation of Radio Waves" (1923-1960)
PA	Science Abstracts: Section A, Physics Abstracts
MGA	Meteorological and Geoastrophysical Abstracts
EI	Engineering Index

IAA	International Aerospace Abstracts
STAR	Scientific and Technical Aerospace Reports (Formerly Technical Publication Announcements)
Excerpt	Excerpt from article
NBS	Semi-Annual Report to Voice of America, NBS Report 7696
JPL	Jet Propulsion Laboratory Astronautics Information Survey
NBSJ	Items reviewed in J. NBS, Sec. D, 1959-1963.
EEMI	Electronic Engineering Master Index
TAB	Technical Abstracts Bulletin

ACKNOWLEDGMENT

It is the editors' privilege to thank the staff of the Literature Research Section of SRI's Library Services for assistance in compiling this report. We especially appreciate the assistance of Miss Marlene Baribault, who assisted in the gathering of the material. We also thank Misses Elizabeth Feinler and Zara Graham and Mrs. Adele Learned, whose combined effort helped make the survey comprehensive and our own task easier.

LIST OF EQUATORIAL IONOSPHERE OBSERVATORIES *

The following is a partial list of stations which are referenced in this report, together with geographic coordinates approximate magnetic inclination (dip angle) and declination (deviation from true north), and the geographic degrees between the magnetic dip and geographic equators for the geographic longitude of the station. The numbers correspond to points on the map of magnetic dip equator. The magnetic data were scaled from U.S. Navy Hydrographic Office Maps 1700 and 1706 (Dip for 1955 and variation for Epoch 1960).

Continent	Country	City and Map Number	Geographic Coordinates		Magnetic Inclination or Dip (Degrees)	Declination (Degrees)	Geographic Degrees Between Magnetic Dip and Geographic Equator †
Africa	Algeria	(1) Tamanrasset	22° 50'N	5° 31'E	26.5 N	5.0 W	12.0
Africa	Central African Republic	(2) Bangui	4° 23'N	18° 37'E	16.2 S	5.0 W	10.[illegible]
Africa	Congo	(3) Bunia	1° 35'N	30° 13'E	21.0 S	[illegible] W	10.0
Africa	Congo	(4) Elisabethville	11° 41'S	27° 29'E	46.0 S	8.4 W	10.0
Africa	Congo	(5) Leopoldville	4° 18'S	15° 19'E	36.0 S	9.0 W	11.0
Africa	Congo	(6) Lwiro	2° 5'S	28° 5'E	30.5 S	5.5 W	10.0
Africa	Egypt (UAR)	(7) Cairo	30° 3'N	31° 15'E	42.1 N	1.2 E	10.0
Africa	Egypt (UAR)	(8) Helwan	29° 51'N	31° 20'E	42.1 N	1.2 E	10.0
Africa	Ethiopia	(9) Addis Ababa	9° 0'N	38° 4'E	1.0 S	2.5 W	9.5
Africa	Ethiopia	(10) Asmara	15° 2'N	38° 0'E	15.2 N	0.5 E	9.5
Africa	French Somaliland	(11) Djibouti	11° 35'N	[illegible] 11'E	6.0 N	1.0 W	10.0
Africa	Ghana	(12) Accra	5° 33'N	0° 15'W	12.8 S	11.0 W	11.0
Africa	Ghana	(13) Achimoto	5° 35'N	0° 15'W	12.0 S	10.9 W	11.0
Africa	Ghana	(14) Kumasi	6° 45'N	1° 35'W	11.2 S	10.9 [illegible]	11.0
Africa	Kenya	(15) Moyale	3° 31'N	39° 04'E	14.8 S	1.7 W	9.5
Africa	Kenya	(16) Nairobi	1° 15'S	36° 49'E	25.5 S	2.6 W	9.3
Africa	Malagasy Republic	(17) Tananarive	18° 52'S	47° 30'E	54.5 S	12.0 W	8.8

* Other observations mentioned in the bibliography are also included

† Denotes areas where magnetic equator is south of geographic equator

LIST OF EQUATORIAL IONOSPHERE OBSERVATORIES Continued

Continent	Country	City and Map Number	Geographic Coordinates		Magnetic Inclination or Dip (Degrees)	Declination (Degrees)	Geographic Degrees Between Magnetic Dip and Geographic Equator*
Africa	Morroco	(18) Casablanca	33° 39'N	7° 35'W	52.0 N	9.3 W	10.0
Africa	Morroco	(19) Rabat	34° 2'N	6° 51'W	51.3 N	[illegible] W	10.0
Africa	Nigeria	(20) Ibadan	7° 23'N	3° 56'E	5.0 S	9.0 W	[illegible]
Africa	Rhodesia	(21) Salisbury	17° 43'S	31° [illegible]'E	[illegible] S	10.9 W	[illegible]
Africa	Senegal	(22) Dakar	14° 38'N	17° 27'W	[illegible]	15.[illegible] W	[illegible]
Africa	Sierra Leone	(23) Freetown	8° 30'N	13° 17'W	[illegible]	[illegible] W	[illegible]
Africa	South Africa	(24) Cape Town	34° 56'S	1[illegible]° 28'E	[illegible].3 S	24.7 W	[illegible]
Africa	South Africa	(25) Grahamstown	33° 19'S	2[illegible]° 32'E	64.0 S	2[illegible].1 W	10.[illegible]
Africa	South Africa	(26) Johannesburg	26° 10'S	2[illegible]° 2'E	[illegible] S	22.2 W	10.[illegible]
Africa	Southwest Africa	(27) Tsumeb	19° 13'S	1[illegible]° 42'E	56.2 S	16.3 W	11.0
Africa	Sudan	(28) Khartoum	15° 33'N	32° 35'E	13.8 N	0.5 W	10.0
Africa	Tunisia	(29) Bizerte	37° 18'N	9° 52'E	52.0 N	3.2 W	12.0
Asia	China	(30) Hong Kong	22° [illegible]'N	11[illegible]° [illegible]'E	30.0 N	0.5 W	[illegible]
Asia	China	(31) Canton	23° 8'N	113° [illegible]'E	31.[illegible] N	1.0 W	[illegible]
Asia	China	(32) Chungking	29° 35'N	106° 36'E	42.0 N	1.9 W	[illegible].3
Asia	China	(33) Manchouli	49° 36'N	117° 28'E	6[illegible].2 N	8.0 W	[illegible].3
Asia	China	(34) Nanking	32° 5'N	118° 46'E	46.0 N	3.8 W	[illegible].3
Asia	China	(35) Peking	39° 55'N	116° 25'E	57.2 N	5.3 W	[illegible].3
Asia	China	(36) Wuhan	30° 35'N	114° 19'E	41.5 N	2.3 W	[illegible].3
Asia	India	(37) Ahmedabad	22° 3'N	72° 4'E	31.7 N	0.5 W	9.[illegible]
Asia	India	(38) Alibag	18° 38'N	72° 55'E	24.0 N	1.3 W	9.4
Asia	India	(39) Allahabad	25° 57'N	81° 50'E	37.0 N	1.0 W	9.3

LIST OF EQUATORIAL IONOSPHERE OBSERVATORIES Continued

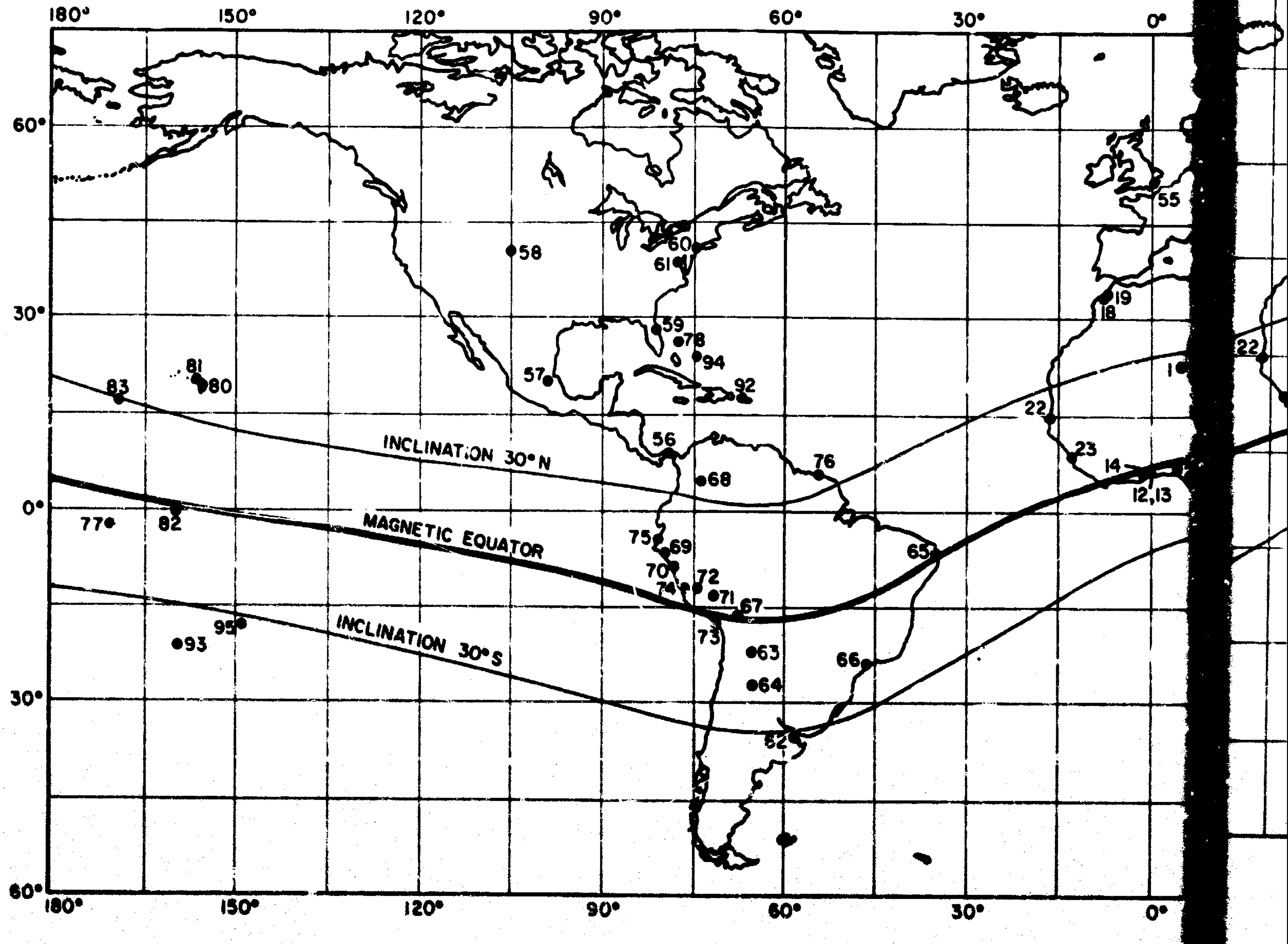
Continent	Country	City and Map Number	Geographic Coordinates		Magnetic Inclination or Dip (Degrees)	Declination (Degrees)	Geographic Degrees Between Magnetic Dip and Geographic Equator*
Asia	India	(40) Calcutta	22° 35'N	88° 21'E	30.0 N	1.7 W	9.5
Asia	India	(41) Dacca	23° 42'N	90° 2'E	30.5 N	1.5 W	10.0
Asia	India	(42) Delhi	28° 39'N	77° 13'E	42.0 N	0.0	9.5
Asia	India	(43) Kodaikanal	10° 15'N	77° 31'E	2.5 N	3.6 W	9.5
Asia	India	(44) Madras	13° 5'N	80° 18'E	9.5 N	3.2 W	9.5
Asia	India	(45) Poona	18° 34'N	73° 58'E	20.5 N	2.0 W	9.0
Asia	India	(46) Tiruchirappalli	10° 5'N	78° 43'E	3.5 N	3.7 W	9.5
Asia	India	(47) Tirupati	13° 39'N	79° 25'E	10.0 N	3.2 W	9.2
Asia	India	(48) Trivandrum	8° 41'N	76° 57'E	1.5 S	4.25 W	9.4
Asia	India	(49) Waltair	17° 45'N	83° 25'E	21.5 N	2.5 W	9.5
Asia	Singapore	(50) Singapore	1° 5'N	104° E	18.0 S	0.75 E	9.5
Asia	Thailand	(51) Bangkok	13° 44'N	100° 3'E	10.0 N	0.0	9.5
Australia	Australia	(52) Brisbane	27° 3'S	153° E	56.8 S	9.8 E	6.0
Australia	Australia	(53) Townsville	19° 13'S	146° 48'E	47.5 S	6.8 E	6.7
Australia	Australia	(54) Watheroo	30° 19'S	116° 3'E	65.9 S	2.3 W	8.0
Europe	England	(55) Slough	51° 31'N	0° 36'W	66.6 N	8.2 W	12.4
North America	Canal Zone	(56) Balboa	8° 57'N	79° 33'W	39.0 N	3.2 E	11.0
North America	Mexico	(57) El Cerrillo	19° 28'N	99° 10'W	47.0 N	9.0 E	6.5*
North America	USA	(58) Boulder, Colo.	40° 2'N	105° 16'W	68.1 N	13.8 E	5.1*
North America	USA	(59) Cape Kennedy	28° 24'N	80° 36'W	61.5 N	0.0	11.4*
North America	USA	(60) Ft. Monmouth	40° 24'N	74° 4'W	71.7 N	10.5 W	12.0*
North America	USA	(61) Washington, D.C.	38° 55'N	77° W	71.0 N	8.2 W	12.0*

LIST OF EQUATORIAL IONOSPHERE OBSERVATORIES Continued

Continent	Country	City and Map Number	Geographic Coordinates		Magnetic Inclination or Dip (Degrees)	Declination (Degrees)	Geographic Degrees Between Magnetic Dip and Geographic Equator*
South America	Argentina	(62) Buenos Aires	34° 40'S	58° 30'W	30.7 S	0.0	12.8°
South America	Argentina	(63) La Quiaca	22° 8'S	65° 35'W	14.0 S	1.5 E	14.0°
South America	Argentina	(64) Tucuman	26° 54'S	65° 24'W	20.0 S	2.5 E	14.0°
South America	Brazil	(65) Natal	5° 46'S	35° 15'W	1.5 S	21.1 W	5.8°
South America	Brazil	(66) Sao Paulo	23° 33'S	46° 39'W	20.8 S	13.3 W	10.0°
South America	Bolivia	(67) La Paz	16° 30'S	68° 10'W	5.0 S	1.9 E	13.9°
South America	Colombia	(68) Bogota	4° 38'N	74° 5'W	32.0 N	1.0 E	12.3°
South America	Peru	(69) Chiclayo	6° 47'S	79° 47'W	5.5 N	6.0 E	11.2°
South America	Peru	(70) Chimbote	9° 4'S	78° 34'W	5.5 N	5.9 E	11.7°
South America	Peru	(71) Cusco	13° 32'S	71° 57'W	0.3 S	3.2 E	13.0°
South America	Peru	(72) Huancayo	12° 3'S	75° 12'W	0	5.25 E	12.6°
South America	Peru	(73) Ilo	17° 42'S	71° 20'W	7.5 S	4.0 E	13.6°
South America	Peru	(74) Lima	12° 6'S	77° 3'W	0	6.0 E	12.2°
South America	Peru	(75) Talara	4° 29'S	81° 18'W	13.5 N	6.3 E	11.8°
South America	Surinam	(76) Paramaribo	5° 52'N	55° 12'W	32.0 N	11.7 W	13.0°
Islands							
Canton	UK/USA	(77)	2° 5'S	171° 4'W	8 S	5.9 E	0.7
Grand Bahama	UK	(78)	26° 36'N	78° 12'W	60.0 N	1.0 W	11.6°
Guam	USA	(79)	13° 3'N	144° 4'E	14.0 N	1.6 E	6.7
Maui, Hawaii	USA	(80)	20° 46'N	156° 20'W	38.0 N	11.2 E	1.0°
Oahu, Hawaii	USA	(81) Honolulu	21° 19'N	157° 5'W	38.5 N	11.2 E	1.0°
Jarvis	USA	(82)	0° 30'N	160° 0'W	0.0	9.8 E	0.5°

LIST OF EQUATORIAL IONOSPHERE OBSERVATORIES Concluded

Island	Country	City and Map Number	Geographic Coordinates		Magnetic Inclination or Dip (Degrees)	Declination (Degrees)	Geographic Degrees Between Magnetic Dip and Geographic Equator*
Johnston	USA	(83)	16° 45'N	169° 32'W	30.0 N	10.0 E	0.5
Macao	Portugal	(84) Macao	22° 15'N	113° 36'E	29.2 N	0.0 W	8.7
New Caledonia	France	(85) Noumea	22° 15'S	166° 28'E	47.5 S	11.5 E	4.2
New Guinea	Netherlands	(86) Hollandia	2° 37'S	140° 39'E	18.0 S	3.5 E	6.9
New Guinea	Australia	(87) Port Moresby	9° 30'S	147° 7'E	31.5 S	5.3 E	6.8
New Zealand	New Zealand	(88) Godley Head (Christchurch)	43° 35'S	172° 48'E	66.8 S	20.5 E	3.5
Okinawa	USA (United Nations)	(89)	26° 54'N	127° 5'E	37.5 N	2.9 W	7.0
Palau	USA	(90) Koror	7° 21'N	134° 31'E	1.0 N	1.8 E	7.0
Philippines	Philippines	(91) Manila	14° 36'N	120° 59'E	15.5 N	0.7 E	8.0
Puerto Rico	USA	(92) Mayaguez	18° 13'N	67° 09'W	51.2 N	6.9 W	14.2*
Rarotonga	New Zealand	(93)	21° 12'S	159° 48'W	39.0 S	13.7 E	1.0*
San Salvador	UK	(94)	24° 0'N	74° 32'W	57.5 N	3.0 W	2.2*
Tahiti	France	(95)	17° 30'S	149° 18'W	31.0 S	12.7 E	1.4*
Taiwan	China	(96) Taipei	25° 05'N	121° 32'E	35.5 N	2.1 W	8.0
Zanzibar	Tanzania	(97)	6° 0'S	39° 2'E	36.0 S	4.0 W	9.4



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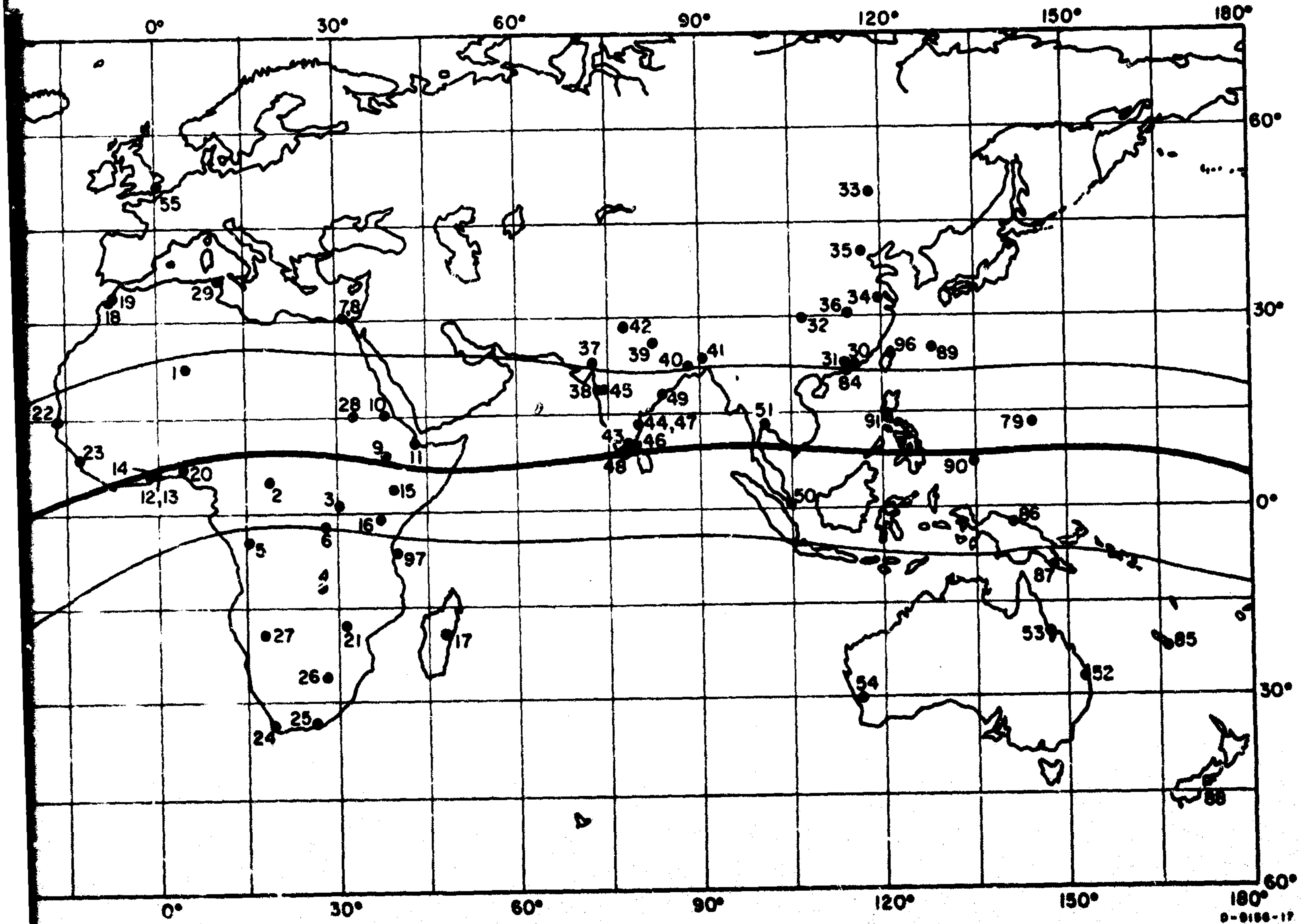

FIG. 1 MAP OF MAGNETIC DIP EQUATOR AND IONOSPHERE OBSERVATORIES

GYROFREQUENCY CALCULATIONS

One can calculate the approximate electron gyrofrequency at ionospheric heights given the total field intensity at the earth's surface (assuming a cubic law decay for a dipole field) with the following formula:

$$\omega_H = \frac{\mu o \text{ Ho } e}{m}\left[\frac{Re}{Re+h}\right]^3$$

$$\omega_H = 1.759 \text{ Bo}\left[\frac{Re}{Re+h}\right]^3 \times 10^7 \text{ radian per second}$$

B_o = Earth's static magnetic field in gauss

$e = 1.602 \times 10^{-19}$ = electronic charge in coulombs

$m = 9.1066 \times 10^{-31}$ = electronic rest mass in kilograms

where

$\mu_o = 4\pi \times 10^{-7}$ = magnetic permeability of vacuum in henrys per meter

Re = 6370 = radius of earth in kilometers

h = height above mean sea level in kilometers

Example: Bangkok, Thailand

Bo ≅ 0.41 gauss

$\omega_H = 1.759 \times 0.41 \times 10^7 = 7.2 \times 10^6$ radian per second (ground)

$f_H = \frac{\omega_H}{2\pi} = 1.145$ Mc (ground)

At E layer heights (100 km)

$$f_H \cong 1.145 \times 0.9542 \cong 1.09 \text{ Mc}$$

At F layer heights (300 km)

$$f_H \cong 1.145 \times 0.8710 \cong 1.00 \text{ Mc}$$

Table I gives values for the altitude decay factor $\left[\frac{Re}{Re+h}\right]^3$, assuming $Re = 6370$ km

Table I. Dipole Field Decay Factor (Geomagnetic Field)

h (km)	$\left[\frac{6370}{6370 + h}\right]^3$	h (km)	$\left[\frac{6370}{6370 + h}\right]^3$
60	0.9722	190	0.9155
70	0.9676	200	0.9115
80	0.9633	210	0.9073
90	0.9589	220	0.9031
100	0.9542	230	0.8992
110	0.9499	240	0.8950
120	0.9455	250	0.8908
130	0.9412	260	0.8869
140	0.9369	270	0.8828
150	0.9325	280	0.8790
160	0.9283	290	0.8751
170	0.9240	300	0.8710
180	0.9198		

Observe that one can calculate the approximate gyrofrequency for any altitude and any location by taking the appropriate ratio of the 100-km-altitude decay factor to the factor for the altitude of interest and multiplying by the 100-km gyrofrequency value for that location (from the World Gyrofrequency Map at 100 km).

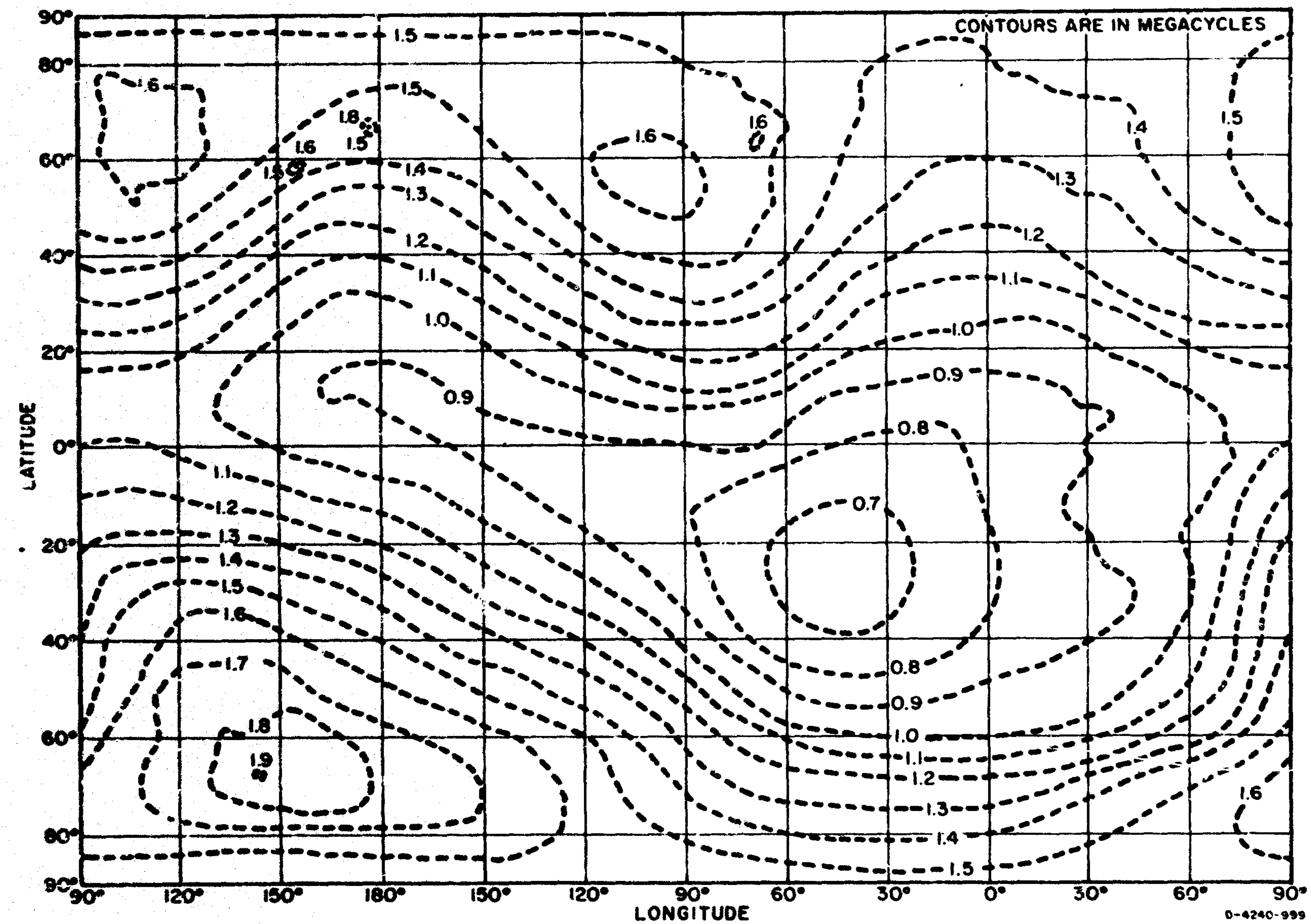

FIG. 2 WORLD GYROFREQUENCY MAP AT 100 Km

ABHIRAMA Reddy, C., and B. Ramachandra Rao. Polarization characteristics of E_s-echoes at Waltair. J. Atmos. Terrest. Phys. 24, 401-406 (1962).

Polarization measurements on high frequency radio waves (2-8 Mc/s) reflected from blanketing and semitransparent types of E_s show that the blanketing type of E_s reflects both the magnetoionic components, while the semi-transparent type reflects in general more of the extraordinary than the ordinary component, the X-magnetoionic component alone being reflected on a good number of occasions.
A

ABHIRAMA Reddy, C., and B. Ramachandra Rao. The observed polarisation of high frequency radio waves at a low latitude station. J. Atmos. Terrest. Phys. 25, 13-22 (1963).

Systematic polarisation measurements on vertical incidence pulsed signals in the 2-4.6 Mc/s range has shown that the observed polarisation is essentially the same as that predicted by the magneto-ionic theory. The small discrepancies observed are explained as arising due to the contamination, on many occasions, of the apparently pure echo under observation by a weak component undetectable on the monitoring A 'scope.
A

ABHIRAMA Reddy, C. The structure of E_s at a low latitude station as deduced from polarization observations. J. Atmos. Terrest. Phys. 25, 387-391 (1963).

The probable structures for different types of sporadic-E are discussed in the light of the measured polarizations of E_s-echoes. The observed polarizations clearly suggest a "thin layer" structure with a sharp gradient for the semi-transparent type of E_s which is of most frequent occurrence at this low latitude station (Waltair).
A

ABHIRAMA Reddy, C. Observation of Z-echo at Waltair. J. Atmos. Terrest. Phys. 25, 467-468 (1963).

Systematic polarisation measurements were carried out at this station (Waltair) using the standard cathode ray polarimeter technique (Abhirama Reddy and Ramachandra Rao, 1963). Throughout the 17-month period of these measurements, the author has been on the look out for the possible occurrence of a Z-echo. The triple splitting of the F-echo has been observed, under normal ionospheric conditions, only on a single occasion. This was at 0335 hours (Indian Standard Time) on September 1961 at a wave frequency of 2.65 Mc/s. The observation at 0300 hours prior to the

above occurrence had shown normal O, X splitting of the echo at 3.2 Mc/s but an unresolved echo at 2.65 Mc/s. The triple splitting of the echo, as observed on the monitoring A' scope, is shown in Fig. 1(a), while the polarisation ellipses of the three echoes are shown in Figs. 1(d), (e) and (f). The highest echo in Fig. 1(a) was strongest of the three for about a minute (at 0335 hours) and its polarisation ellipse (d) was taken in this condition with the "sense detector" circuit in operation; the quenching of the lower half of the ellipse indicates left-handed (ordinary) rotation of the field vectors. Then the Z-echo became reduced in strength, as seen in Fig. 1(a), and after about 5 min it disappeared rather suddenly. The other two echoes persisted without any change as shown in Figs. 1(b) and (c), and their polarisation ellipses in Figs. 1(e) and (f) clearly show that the lowest echo was extraordinary and the higher on the ordinary. The above observations were taken under severe noise conditions on comparatively weak echoes; still the polarisation ellipses of all the echoes were quite stable and the sense of rotation of each was unambiguous. These observations clearly show that the short-lived highest echo in Fig. 1(a) is the Z-echo. The occurrence of such a third echo cannot be attributed to any ionospheric irregularities (spread-F, travelling wave disturbances, etc.) because very steady specular reflections of well-resolved O, X components were observed prior to and after the observations at 0335 hours. Further, hourly observations in the frequency range of 1-14 Mc/s were being made during this night starting from 1900 hours (I.S.T.) in the evening and no occurrence of spread-F or other irregular reflections was observed at any hour (Krishnamurthy). Thus, the above triple splitting of the echo took place under quiet ionospheric conditions at the place of observation.

Eckersley (1950) and Rydbeck (1950) have explained the common occurrence of the Z-echo at high latitudes on the basis of "coupling" between the ordinary and extraordinary waves at a level in the ionosphere where the condition

$$\left.\begin{aligned} v &= v_c \\ x &= 1 \end{aligned}\right\} \qquad (1)$$

is satisfied, v and v_c being the collisional frequency and the critical collisional frequency, respectively. The above coupling process alone cannot accout for the triple splitting which is observed many times at moderately high latitudes (Ellis, 1953), and occasionally even at middle and low latitudes (Satyanarayana et al. 1959; Toshniwal, 1935), for the condition characterised in equation (1) cannot be satisfied at the lower latitudes. Scott (1950) and later Ellis (1956) have put forth a modified explanation of the Z-echo occurrence at moderate and low latitudes. Ellis (1953) confirmed the correctness of his explanation by his experimental measurements on the angle of arrival of these Z-echos (see Ratcliffe, 1959).

From the above it is clear that even a rare occurrence of the Z-echo at such a low latitude station as Waltair (dip angle 20°) is of much significance as it would provide important experimental evidence for the existence of other possible mechanisms of Z-echo occurrence in addition to the "coupling" process considered by Rydbeck and Eckersley. No detailed discussion about the origin of the Z-echo observed at Waltair is attempted here, but the observation shows clearly that there are other processes at work – apart from the "coupling" process – which are capable of giving rise to a Z-echo even at a low latitude station.
A

ABHIRAMA Reddy, C. Theoretical polarisations of high frequency radio waves at a low latitude station. Indian J. Phys. 37, 430-439 (Aug. 1963).

The polarizations of vertically propagated high-frequency radio waves have been evaluated from the Appleton-Hartree formula for the latitude of Waltair (Geomagnetic Lat. 7.4°N, Dip angle 20°) by the rigorous computational method. The variations of the axial ratio and the tilt angle of the polarization ellipse with electron density, collisional frequency and wave frequency are directly delineated so as to make possible a ready comparison with experimentally measured values of the above parameters.
PA

AGY, V., and J. DeGregorio. HF propagation over an 8,500 km path. IN: Semi-annual Report to Voice of America, Port B, Africa Ionosphere, NBS Rept. 7276, National Bureau of Standards, 4-31 (July 1962).

In March and April 1961, as part of the NBS-USIA African Ionosphere program, measurements were made which were to give approximate information on HF propagation mode structure and transmission loss over a United States – West Africa path similar to that soon to be used by the Voice of America. High powered pulse transmissions (about 150 kw) on 17.5 Mc/s from Sterling, Virginia were received at Accra, Ghana where relative time delays of the received pulses were recorded. 100 μsec pulses with a repetition rate of 25 per second were used. The antennas were identical sloping V's with a major lobe maximizing at about 12° elevation. The intervals in time delay shown on the film records are 666 μsec, or 200 km in equivalent or group path (P'). The great circle distance between Sterling and Accra is just over 8,500 km. In addition, signal strength measurements of WWV-20 (Beltsville, Maryland) were made at Accra. The path is shown on the map in Figure 1.
Excerpt

AID. Radio Wave Propagation, Bibliography of USSR Publications for 1958-1960. Rept. 61-150 (7 November 1961). AD-267 928.

A bibliography is presented based on USSR publications (monographs, monographic serials, and periodicals) for 1958-1960. It contains 261 entries divided into three parts and arranged alphabetically by authors within each part. Titles of monographs are given in Russian followed by an English translation. Annotations are provided when clarification is considered desirable. The entries are grouped under three headings: Propagation in general, Propagation in the troposphere, and Propagation in the ionosphere.
A

AID. Ionospheric Disturbances. Rept. 62-76 Aerospce Information Division, Library of Congress, Washington, D.C. (11 June 1962). AD-288 969.

No abstract available.

AID. Phenomena in the Upper Atmosphere. Review of Soviet Literature. Monthly Rept. 37, AID Rept. 63-98, Air Information Division, Library of Congress, Washington, D.C. (July 25, 1963).

This review on Soviet developments in astrophysics and geophysics covers the following main topics: (1) solar radiation and the ionosphere; (2) atmospheric electricity; and (3) the meteorology of the upper atmosphere. Discussion of solar radiation and the ionosphere include the following papers: Investigations of the Heterogeneous Structure and Movements in the Ionosphere above Ashkabad at Heights from 200 to 400 km, Carried out According to the IGY and IGC Program in 1958-1959; Solar Activity and the General Function of the Terrestrial Atmosphere; the Connection between F2 Layer Disturbances and Planetary Magnetic Activity; Theoretical Investigations of the Structure of the F2 Layer and the Outer Ionosphere; and Characteristics of the Sporadic E Layer of the Ionosphere above Ashkhabad during the IGY and IGC (1957-1959). Papers conerning atmospheric electricity include the following: On the Horizontal Components of the Atmospheric Electric Field near a Flat Ground Surface. The meteorology of the upper atmosphere is discussed in the following papers: the Application of Kinetic Gas Equations to the Study of the Properties of the Upper Atmosphere; On the Effect of Atom Recombination within an Instrument on the Measurement of the Composition and Density of the Upper Atmosphere Layers; and the Evaluation of the Effect of Non-equilibrium of an Atmosphere on the Measurement of its Structural Parameters.
A
Similar monthly reports have appeared since July 1960.

AKASOFU, S., and Sydney Chapman. The ring current, geomagnetic disturbance, and the Van Allen radiation belts. J. Geophys. Res. 66, 1321-1350 (1961).

The large decrease in the horizontal component of the earth's field during the main phase of magnetic storms has been ascribed to the formation or enhancement of a geomagnetic ring current. In this paper we discuss the motions of particles trapped in the earth's dipole field and the resulting ring current. These calculations deal only with a steady state, though during storms the state is changing. The general equations for the current intensity, to obtain the total current and the magnetic field at the earth's center, are applied to the outer radiation belt (V_2) and to a special 'model' belt V_3. This V_3 belt has a particular type of pitch-angle distribution and a number-intensity distribution of Gaussian type along an equatorial radius. The results are considered in connection with magnetic records for several storms and with satellite data. We infer that, during magnetic disturbance, protons of energy of the order of a few hundred kev are intermittently captured between 5 and 8 earth radii and that they produce a transient belt V_3. The variety of development of the ring current from one storm to another may be connected with irregularities in the distribution of particles in the solar stream, which may contain tangled magnetic fields.
A

AKASOFU, S., J.C. Cain, and S. Chapman. Magnetic field of the quiet-time proton belt. J. Geophys. Res. 67, 2645-2647 (1962).

The distortion of the Earth's magnetic field produced by the proton belt is discussed. The magnetic field is calculated numerically, to a first approximation, for an analogous model belt in a steady state. It is estimated that in the equatorial plane, at the Earth's surface, the magnetic field produced by this belt is of the order of 38γ. It is directed southward. The maximum field reduction is of the order of 72γ at 4.1_a (a = Earth's radius); this is 15.5% of the dipole field intensity at this point. Beyond 6.7_a, the belt increases the Earth's field.
MGA

AKASOFU, S., and S. Chapman. The enhancement of the equatorial electrojet during polar magnetic substorms. J. Geophys. Res. 68, 2375-2382 (1963).

It is shown that the growth of auroral electrojets can greatly enhance the equatorial electrojet. This indicates that a part of the return current, spreading from the auroral zone to the ionosphere in low and middle latitudes, can extend to as far as the late afternoon side along the magnetic equator. The current systems inferred so far for polar magnetic substorms

may have to be revised to include such an intense return current. The enhancement is used to infer the distribution of the highly conductive region along the magnetic equator. It is shown that the conductivity is about 4-7 times higher there than in middle latitudes.
A

ALEXANDER, N. S., and C. A. Onwumechilli. Variation of the horizontal force near the magnetic equator. Nature 180, 191-192 (1957).

Measurements of the variation of the horizontal component of the earth's magnetic field H at latitudes between 3°N and 3°S of the magnetic equator can be explained by the superposition of the effects of a narrow equatorial electro-jet on a more general field which varies appreciably with latitude. The results suggest that fluctuations in H arise mainly from minor fluctuations of the electro-jet itself. The equatorial electro-jet must be very narrow, probably 2-3° wide.
PA

ALLCOCK, G. McK. The prediction of maximum usable frequencies for radiocommunication over a transequatorial path. Proc. IEE 103B, 547-552 (1956).

Times of reception of 15 Mc/s radio waves over a transequatorial path of 7500 km have been recorded throughout the recent period of declining solar activity (1950-54). The analysis of these times has shown that predictions of maximum usable frequency (m.u.f.) made by the usual control-point method were, in general, too high by about 4 Mc/s, and at times by as much as 7Mc/s or more. This is contrary to the normal experience for long transmission paths lying within a single hemisphere. When a transmission mechanism involving multiple geometrical reflections is assumed instead of the forward scattering mechanism implied by the control-point method, it is found that the path can be considered, for the purpose of predicting m.u.f.'s, to consist of three reflections. The discrepancies between prediction and observation, which still remain after a 3-reflection mechanism has been invoked, are attributed mainly to reflections from the sporadic-E region at the southermost reflection point, although it is possible that lateral deviation of the radio waves is also a contributing factor.
EEA

ALLEN, C. W. Variation of the sun's ultra-violet radiation as revealed by ionospheric and geomagnetic observations. Terrest. Mag. Atmos. Elec. 51, 1-18 (1946).

A study has been made of the short- and long-period variations of critical frequencies of the E-, F1-, and F2-ionospheric layers at Washington, Huancayo, Watheroo, and Mount Stromlo during 1937-44. Terrestrial factors have been eliminated in order that the frequencies should represent the changes in the ionising ultra-violet light. A similar study has also been made of the variations in the amplitude of the S_q magnetic field at Apia, Watheroo, and Cape Town during 1937-43. Yearly, monthly, and daily variations have been compared with solar data by means of graphs and correlation-methods. The following are the main conclusions:

(a) The variable part of the Sun's ultra-violet illumination comes mainly from active regions characterised by the appearance of sunspots, flocculi, and faculae.

(b) The sources of ultra-violet have a longer life than sunspots, and possibly a longer life than faculae.

(c) The three ionospheric layers E, F1, and F2, and the S_q-field are influenced by the same sources of ultra-violet light.

(d) The sources emit considerable ultra-violet radiation when at the center of the Sun and probably emit some radiation when near the limb.

(e) F2 electrons take periods of one or two days to reach equilibrium concentration — at the level of S_q-currents recombination is much more rapid.

(f) The variable part of the ultra-violet flux is proportional to sunspot-number, and is about equal to the steady part at sunspot-maximum. This applies to radiation exciting the E-, F1-, and F2-regions.

(g) There is a linear relation between f_0F2 and sunspot-number.

(h) Faculae could produce continuous ultra-violet radiation that might account for ionospheric and geomagnetic variations.

ALLEN, C. W. World-wide diurnal variations in the F2 region, J. Atmos. Terrest. Phys. 4, 53-67 (1953).

A study has been made of the diurnal variations of F2 critical frequencies and virtual heights as a function of phase of sunspot cycle, season, and geographic and geomagnetic position. The main results are derived from ten stations that are well observed at both sunspot maximum and minimum.

The chief characteristics of f^0F2 may be described in terms of (a) the sunspot minimum anomaly, (b) the sunrise anomaly, and (c) the diurnal range anomaly. The features of these anomalies are evaluated quantitatively and then as far as possible, the anomalies are extracted from the data to determine the normal curves. The world distributions of indices representing the anomalies are studied. The variations of the F2 virtual height are not related in any very significant manner to either the sunspot cycle or the f^0F2 diurnal curves.

Some attempt at explanation of the anomalies has been made but no complete theory is available. Some effects are thought to be thermal or tidal oscillations, and evidence is given for the conclusion that F2 electrons disappear by a decay law that is independent of gas pressure.
A

ALTMAN, C., J. Duvshani, and H. Cory. Proc. Israel 5th Annual Conference on Aviation and Astronautics. Jerusalem, 1963, 110-119.

Integration of ionospheric profiles of electron density vs height to yield total (sub-peak) ionospheric electron content at constant solar zenith angles throughout a year for Haifa, Washington, Panama, and Talara and Huancayo, Peru. Results for the first two stations show a typical seasonal anomaly with decreased electron content in local summer. Talara and Huancayo, located respectively on the geographic and magnetic equators, show a similar June-July decrease in electron content, typical of an "annual anomaly" (local winter in Huancayo) rather than a "seasonal anomaly" in the equatorial zone and low latitude southern hemisphere. Results are consistent with values obtained at other stations using ionosonde data, and also with satellite measurements of total ionospheric electron content. It is shown that for medium latitude stations the seasonal anomaly may be explained by the increased summer concentration of molecular nitrogen compared with atomic oxygen in the F_2 region, and that this may be in the main a temperature effect.
Source unknown.

AMERICAN RADIO RELAY LEAGUE. Study of transequatorial scatter propagation. Final Rept. American Radio Relay League (1959).

To collect and utilize observations by amateur radio operators in the very high frequency range, the ARRL-IGY Propagation Research Project was organized. The present paper is a systematic report of how the project was carried out. It discusses in separate chapters the actual nature of the project, setting up of the observing group, data processing, data codes and, finally, the results. It is reported that 593 amateurs, out of 1320 on the project mailing list, actually submitted the semimonthly logs requested. Bands available to them are one or more of the following (depending on location): 50-54, 70-72, 144-148, 220-225 and 420-450 Mc. The data received was duly processed. The project's results consist of 281,640 punched cards with the following (chiefly 50 Mc) propagation modes, auroral reflection, F2-layer back scatter, sporadic E single and double hop, meteor/ionospheric forward scatter and transequatorial scatter. Upon analysis it is found that transequatorial scatter is not limited to the Americas but occurs in many parts of the world, all paths being roughly symmetrical to the geomagnetic equator.
MGA

AMES, J. The correlation between frequency-selective fading and multipath propagation over an ionospheric path. J. Geophys. Res. 68, 759-768 (1963).

When continuous-wave high-frequency radio transmission within a band several kilocycles per second wide is examined it is found that signals fade differently throughout the band. The phenomenon has been known for many years as selective fading. In this report the relationship between selective fading and the relative time delays of the various propagating modes is studied over the 2450-km path from Mayaguez, Puerto Rico, to Smyrna, Georgia. Selective fading was measured by propagating a frequency-modulated CW transmission over the path while the modes propagating, and their structure, were recorded by means of oblique step-frequency soundings. It was confirmed that, when two modes were propagating at the FM-CW frequency, selective-fading nulls were separated in the frequency spectrum by an amount that is the reciprocal of the group time delay between the modes. The FM-CW technique represents an inexpensive means for determining the degree of multipath that exists on a given circuit at a given time. Such soundings, which can be made by simple modification of existing equipment, allow the degree of multipath to be quickly estimated and can also give clear advance warning of impending circuit failure resulting from falling MUF.
A

AONO, Y. Regional anomalies in foF2 of the ionosphere. Rept. Ionos. Space Res. Japan 7, 30-33 (1953).

Regional anomalies in foF2 of the ionosphere are studied by investigating the world-wide distribution of the monthly median values of foF2 at noon plotted on the geomagnetic coordinates, using the ionospheric data over the world throughout four years from 1946 to 1950, exclusive of a year of 1949 In plotting the world-wide distribution on the map, at first the ratios of the monthly median values of foF2 to the highest monthly median value throughout the world are taken for each station, and then these ratios for the same month are averaged for the four years at each station and plotted on the world map of the geomagnetic coordinates. In this treatment, consideration is taken for making some adjustment to the averaged values of the ratios according to the different degrees of importance for the years when the observed data are missing at the station in question. Thus the twelve maps of the world-wide distribution for each month can be obtained by drawing the contour lines for each ten percent step on the world maps. Figs. 1, 2 and 3 show respectively the typical example of winter, equinoxes and summer of this world-wide distribution. Excerpt

APPLETON, E. V. Radio exploration of the ionosphere. Nature 133, 793, (1934).

Radio Exploration of the Ionosphere

(a) Measurement of the earth's magnetic field in the ionosphere.

The discovery of magneto-ionic doubling of wireless echoes returned from the ionosphere and its explanation in terms of the theory of double refraction have provided us with a method of estimating the intensity of the earth's magnetic field at the level from which the waves are reflected. The way in which the earth's magnetic field is related to the observational data was indicated by Appleton and Builder, who showed that, under conditions of quasi-longitudinal propagation, relative to the direction of the magnetic field, we have

$$H = \frac{2\pi m}{e} (f_e - f_0) \quad . \quad . \quad . \quad . \quad . \quad . \quad (1),$$

where H is the total magnetic intensity, f_e and f_0 are respectively the critical penetration frequencies of the extra-ordinary and ordinary waves for any particular region, and e and m are the charge and mass of an electron. For conditions of quasi-transverse propagation, on the other hand, the corresponding formula is

$$H = \frac{2\pi m}{c}\left(\frac{f_e^{\,2} - f_0^{\,2}}{f_e}\right). \qquad (2).$$

It was further shown by Appleton and Builder that their experimental results, obtained under conditions of quasi-transverse propagation, agreed approximately with (2) when the value of the earth's magnetic field at the gound was used for H, so that their observations could be interpreted as indicating either the approximately quantitative correctness of the magneto-ionic theory or that the magnetic field in the ionosphere does not differ very markedly from its value at ground level.

If we assume the quantitative correctness of the magneto-ionic interpretation of the results, it is obvious from equations (1) and (2) that we have here a method of measuring the magnetic field in the ionosphere. During the past year, I have therefore made as careful measurements as possible of the value of H for the upper ionised region during nocturnal conditions when critical frequency measurements are most reliable, my object being to look for small variations of H such as might be caused by the upper-atmospheric currents envisaged in present-day theories of terrestrial-magnetism.

The detailed examination of these results is still in progress, but one result of interest has emerged from the first series of two hundred measurements. The average value of H calculated from (2) is found to be 0.42 gauss. Now the value of the earth's total magnetic field at the surface of the earth in south-east England is 0.467 gauss, so that the radio observations suggest that the average magnetic field in the ionosphere is about 10 per cent less than its value at the ground.

Now, according to Schmidt, the earth's magnetic field intensity above the surface may be expressed, as a first approximation, by H_0 (1— 3h/R) where H_0 is the ground value, h the elevation and R the earth's radius. The values of the magnetic field at 200 and 300 km. above the earth's surface in south-east England should therefore be 0.42 and 0.40 gauss respectively. It will be seen that the value obtained by the radio methods is of about this order of magnitude.

(b) A new method of ionospheric investigation.

One of the fundamental quantities measured in the study of the ionosphere is the group-time for a signal to travel to the stratum of reflection and back

to the ground. To measure such a group-time, we must impress some kind of mark on the signal in order to recognise it on its return. Now the essential characteristics of an electric wave are frequency and amplitude, and the two basic methods of group-time measurement are thus those involving frequency-modulation and amplitude-modulation. It must not be assumed, however, that in their simple forms they always represent the most convenient ways of marking a signal for group-time measurements, and I have recently found that there are sometimes advantages in combining the methods so as to produce a frequency change on a pulse emitter. It will readily be seen that in doing this we extend the frequency range examined in the experiment and obtain, in effect, information comparable with that which we should get with an extremely brief pulse. This means that we can investigate the structure of echoes whch are normally unresolved.

As an example of the use of this combination method, as I propose to call it, let us consider the case of an unresolved magnetio-ionic doublet. If the mean frequency of the emitter is varied continuously through a sufficiently large range, we get interference effects in the echo itself, so that any component amplitude varies through a series of maxima and minima. If, in this case, a linearly polarised receiver aerial is used, we have:

$$c\frac{\Delta n}{\Delta f} = P'_0 - P'_e \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (3)$$

where P'_0 and P'_e are the equivalent paths of the ordinary and extraordinary waves, Δn the number of interference fringes produced by a change of frequency Δf and c is the velocity of light.

When apparatus is available for providing automatic maintenance of sender and receiver tuning during the frequency change, such as that first described by Gilliland, the usefulness of the combination method may be strikingly demonstrated. For example, in a test carried out at Slough at 1530 on March 8, 1934, using an apparatus of similar principle designed by Mr. L. H. Bainbridge-Bell, an alteration of means frequency of from 4.0 to 4.2 mc./s. produced five interference fringes in a first order F-region reflection. This corresponds to an equivalent path difference for the two magneto-ionic components of 7.5 km., or to a difference in equivalent height of 3.75 km. It is obvious that differences in equivalent height of 1 km. or less can be detected in this way.

Excerpt

APPLETON, E.V., and K. Weekes. Lunar tides in the upper atmosphere. Proc. Roy. Soc. 171A, 171-187 (19 May 1939).

Using the well-known radio methods of upper-atmospheric exploration, a lunar tide has been detected in the Kennelly-Heaviside layer (Region E) of the ionosphere. The magnitude and phase of the tide may be specified by the statement that the experimentally determined expression for the equivalent height of the lower boundary of the layer is found to contain a term of the form $0.93 \sin (2t' + 112°)$ km., where t' is the lunar hour angle. The tide is thus semi-diurnal, of the order of 1 km. and attains its maxima about 3/4 hr. before the lunar transits. To the accuracy of the experimental results, it is thus in phase with the lunary barometric pressure oscillations, as determined by Chapman for ground level at Greenwich. Difficulties are encountered in reconciling the new results with what has previously been deduced from other geophysical evidence concerning the magnitude and phase of upper-atmospheric oscillations.
A

APPLETON, E. V., and W. J. G. Beynon. The application of ionospheric data to radio-communication problems: Part I. Phys. Soc. 52, 518-533 (1940).

The reflection of waves obliquely incident on the ionosphere is studied theoretically. A direct method of calculating the maximum usable frequency reflected at oblique incidence by a thick "parabolic" layer, for both short-distance (plane earth) and long-distance (curved earth) transmission, is developed, and the results exhibited graphically. In an appendix it is shown how the thickness of a "parabolic" layer may be deduced from the results of vertical-incidence ionospheric sounding.
A

APPLETON, E. V. Two anomalies in the ionosphere. Nature 157, 691 (25 May 1946).

During the War, many new ionospheric stations were instituted in different parts of the world to serve the operational requirements of the Allied Forces. As a result, there have become available, for the first time, sufficient data to provide a rough general morphological picture of the F_2 layer of the ionosphere. A study of these data has disclosed the remarkable result that, although ionospheric events in the E and F_1 layers are similarly reproduced at the same local time on the same day at all locations on a line of constant geographic latitude, the same is by no means the case for the F_2 layer. It has also been confirmed, as was suspected earlier, that under conditions of symmetrical solar illumination, an

asymmetry of ionization exists for certain station on the same logitude and situated at equal latitudes north and south of the equator.

These phenomena are best illustrated by considering maximum noon ionization densities in the F_2 layer at the equinoxes, when the sun's zenith distance, χ, is the same for equal latitudes north and south of the equator. From a study of this kind for March 1937, it was found that the values of critical frequency fF_2 for Wuchang (lat. 30.5° N.) and Tokyo (lat. 35.6° N.) were definitely higher than those for Watheroo (lat. 30.3° S.) and Sydney (lat. 35.3° S.). An asymmetry of ionization for sites of equal latitudes north and south of the equator, and of roughly the same longitude, was suspected. Many other examples of the same phenomenon have been noted in more recent results.

In 1943, a further anomaly was identified when equinox noon values for two sites of approximately the same northern latitude, but widely different longitudes, were compared. It was found that the fF_2 values for Delhi (lat. 28.5° N., long. 77.1° E.) were substantially higher than those for Baton Rouge (lat. 30.0° N., long. 90.0° W.), indicating a variation of noon ionization with longitude along a line of constant latitude.

These two anomalies are illustrated in Fig. 1, where all the available March 1944 values of fF_2 at noon are plotted as a function of geographical latitude. The values corresponding to a narrow range of longitude (60°-90° W.) are ringed, and the curve drawn through them shows clearly the asymmetry about the geographical equator. The 'longitude effect' is illustrated by the fact that the values for Delhi (lat. 28.5° N.) and for Kihei (lat. 20.8° N.) lie completely off the curve. The longitudes of these two stations are, respectively, 77.1° E. and 156.5° W.

In Fig. 2 the same values are plotted as a function of magnetic dip, and it will be seen that the above-mentioned anomalies in respect of the low-latitude stations have substantially disappeared. A geomagnetic control of fF_2, for low values of sun's zenith distance is therefore indicated. It should, however, be noted that, for higher latitudes and thus for higher values of χ, the longitude effect is practically absent, since fF_2 is more closely related to geographical latitude than to magnetic dip.

Later results, with a greater wealth of data, have confirmed the general shape of the continuous line drawn in Fig. 2, though it is not yet certain whether or not the two maxima reach equal values. It appears that, for noon equinox conditions, there is a belt of low values of fF_2 circling the earth and centred roughly on the magnetic equator. For stations situated within this belt it is found that these low values are associated with marked bifurcation of the F layer into the F_1 and F_2 strata. Such bifurcation is accompanied by the usual phenomena (for example, low noon value, evening concentration of ionization, slow electron disappearance after sunset, etc.) with which we are familiar under English summer conditions. In other words, the longitude effect and the geomagnetic control are exhibited not only in the noon values of fF_2 but also in the whole diurnal behaviour.

A

I am indebted to the collaborating ionospheric authorities in America, Australia, India and New Zealand for permission to use the results of their measurements in the above figures. This work was carried out as part of the programme of the Radio Research Board of the Department of Scientific and Industrial Research.
Excerpt

APPLETON, E. V. Geomagnetic control of F2-layer ionization. Science 106, 17 (1947).

For constant longitude, noon values of ionization at equal north and south latitutdes are not equal. Also, noon ionization depends on longitude for fixed latitude. If equinox noon values of foF2 are plotted vs geomagnetic latitude, above anomalies disappear. In such plot, higher values of ionization density are found near the geomagnetic equator, except for a trough within 18 deg of equator. Reduced densities in equatorial region are associated with bifurcation of F layer into F1 and F2 much as in northern summer. Long-term variation of F2-layer density with sunspot cycle is found, with ratio of maximum to minimum density depending on season. Ratio is 2 in summer, 4 in winter.
M

APPLETON, E. V. Studies of the F_2 layer in the ionosphere. J. Atmos. Terrest. Phys. 1, 106-113 (1950).

The seasonal variations of the noon equivalent heights of the F_2 Layer at a number of stations are examined and the variations characteristic of the northern hemisphere and of the southern hemisphere identified. It is shown that the change-over from one type of variation to the other occurs in a region which is more nearly coincident with the magnetic equator than with the geographical equator.
A

APPLETON, E. V., and W. R. Piggott. World morphology of ionospheric storms. Nature 165, 130-131 (1950).

The manifestation of an ionospheric storm varies with latitude. At high-latitude stations geomagnetic disturbances are accompanied by a negative ionospheric phase (i.e. a decrease in F_2-layer critical frequency). At temperature latitudes the ionospheric storm often exhibits a positive-negative phase sequence and at equatorial stations only a positive phase is observed. The ionospheric changes associated with suddenly commencing disturbances and the influence of ionospheric storms on F_2-layer variability are also briefly discussed.
EEA

APPLETON, E. V., and W. R. Piggott. The morphology of storms in the F2-layer of the ionosphere. I. Some statistical relationships. J. Atmos. Terrest. Phys. 2, 236-252 (1952).

Find F2 critical frequencies above average for two days at beginning of storm. There is then a major depression with a slow recovery. At equatorial stations, however, there is a marked increase in foF2 simultaneously with the temperate zone depression. Find excellent correlation of storm occurrence for stations of same longitude, if in same hemisphere. Find that negative phase of storm starts frequently at 0600 to 0700 local time. Disturbances are relatively rare for high latitude stations in local winter.
M

APPLETON, E. V., and W. R. Piggott. Ionospheric storms and the geomagnetic anomaly in the F2-layer. J. Atmos. Terrest. Phys. 3, 121-123 (1953).

Plot ratio of distrubed to quiet day critical frequency at Wakkavai for November through February, 1949-50. There is a minimum at 0500, a maximum at 2000 local time. Also plot ratio of Ottawa to Wakkavai critical frequencies versus local hour, and obtain roughly similar curve. Ottawa and Wakkavai are at about the same geographic but different geomagnetic latitutdes. Thus suggest that the effect of a storm is to augment the existing geomagnetic anomaly. Fail to support Martyn's statement that during an F-layer storm the Huancayo anomalies are removed, so the layer behaves more like a simple Chapman region.
M

APPLETON, E. V. The anomalous equatorial belt in the F_2-layer. J. Atmos. Terrest. Phys. 5, 348-351 (1954).

An examination of the maximum electron intensity N_m of the F2-layer with time at various magnetic latitudes has shown anomalous effects in an equatorial belt about 4000 km wide. In early morning N_m is a maximum at the equator, decreasing steadily with latitude on either side. As noon approaches a "trough" of relatively low N_m occurs on the equator with "peaks" of N_m at 15-20° latitude N-S. In the late evening this trough is replaced by a crest which disappears rapidly after midnight. The trough and crest are explained as the results of the vertical expansion and contraction of the F2-layer.
PA

APPLETON, E. V., A. J. Lyon, and A. G. P chard. Th ation of the S_q current system in ionospheric radio sounding. J. Atmos. Terrest. Phys. 7, 292-295 (1955).

Using the results now available from the world's ionosphere stations, a critical examination of the behaviour of the E-layer of the ionosphere has been conducted with the object of discovering how far such behaviour is explicable in terms of Chapman's classical theory certainly gives a broad general explanation of E-layer phenomena, a number of anomalies have been identified which indicate the operation of certain perturbing factors not envisaged in its formulation. Some of these anomalies have already been reported (Appleton, 1955). The present not deals with the results of a further examination of one of them namely the effect of electron transport phenomena on diurnal variations of maximum electron density.
Excerpt

APPLETON, E. V. Storms in the ionosphere. Endeavour 14, 24-28 (1955).

The author describes (1) the experimental radio-sounding of the ionosphere for ionospheric forecasting giving the equations for the conditions of reflection at vertical incidence for the ordinary case and for the extra-ordinary case; (2) the characteristics of the E and F layers; (3) behaviour of ionosphere layers at high latitudes; (4) the characteristics of ionospheric stormy conditions in equatorial regions; (5) the variation of electron density at noon in the E, F, and F2 layers: (6) the practical implications of storm changes in the F2 layer in relation to radio circuits and (7) the possible physical mechanisms of ionospheric storms.
MGA

APPLETON, E. V. Regularities in the ionosphere. IN: Beer, A., ed. Vistas in Astronomy. 2, 779-790 (Pergamon Press, London, 1956).

A general survey of ionospheric phenomena is given, in which the regular variations of the E and F_1 layers, as illustrated by their intimate dependence on the sun's zenith distance, are contrasted with the anomalous behavior of the F_2 layer. Using results from the world's ionospheric stations, such anomalous behavior is identified as geomagnetic distortion, most probably due to atmospheric tidal action operating on a ionized medium in the presence of the earth's magnetic field. As an illustration of such geomagnetic control it is shown that, in the F_2 layer, the region of change-over from the Northern to the Southern Hemisphere type of variation is more nearly coincident with the magnetic equator than with the geographic equator.
MGA

APPLETON, E. V. Equatorial anomalies in the F2 layer of the ionosphere. IN: Beynon, W. J. G., ed., Some Ionospheric Results Obtained During the IGY, Proc. Symposium URSI/AGI Committee, Brussels, Sept. 1959, 3-7 (Elsevier Publishing Co., New York, 1960).

Anomalies characteristic of the F2 layer in the equatorial belt centered between ±20° magnetic latitude were investigated. Three aspects of F2 morphology associated with equatorial conditions were briefly described. The observed geomagnetic distortions were correlated with electron transport along the Earth's magnetic force lines. Equatorial data for 1958, a year of sun spot maximum, used for plots of fF2 with magnetic latitude, have shown that the equatorial "trough" is more extensively exhibited than at sunspot minimum. A remarkable sequence of height changes in the F-layer during the evening hours was observed at the magnetic equator simultaneously with a peculiar signal enhancement in the F-layer scatter transmission. The phenomenon vanishes toward the ±20° latitude. The evening height anomaly was related to Solar activities. The investigated sunspot cycle ratio of fF2 exhibited anomalous variations which are plotted on graphs. Particularly at midnight two striking maxima were evident at the edges of the anomalous equatorial belt. The analysis of these phenomena indicated the existence of a meridional electron transport, first suggested by E. K. Mitra (Nature, 158:688, 1946) in addition to the vertical drift of tidal origin. These conclusions were confirmed by observations at Panama and Huancayo.
MGA

APPLETON, E. V. and A. J. Lyon. [Stu]dies of the E-layer of the ionosphere-II. Electromagnetic perturbations and other anomalies. J. Atmos. Terrest. Phys. 21, 73-99 (1961).

An extended, and more detailed, account is given of a result, first described by the authors some years ago: namely, that the electromagnetic influence of the S_q system of currents can be detected in studies of E-layer morphology. This result has been subsequently confirmed by Beynon and Brown, and by Shimazaki.

Part I of this paper was devoted to the derivation of various quantitative relations by which the experimentally observed behaviour of the E-layer could be explained in terms of current theories of ionized layer formation and variation. It was there shown that two valuable criteria in this connection are (a) the nature of the diurnal asymmetry of $N_m(E)$ when corresponding forenoon and afternoon values are compared and (b) the dependence of the mean level of $N_m(E)$, the layer maximum electron density, on cos χ, where χ is the solar zenith distance.

Departures from the predictions of simple theory have been identified by comparing E-layer characteristics observable at different times at a given station, and at the same time at different stations. For example, studies of diurnal asymmetry in f_0E and h'E indicate departures from theoretical predictions; and, moreover, disclose opposite trends in high and low latitudes which we identify as geomagnetic perturbations arising from the motor effect of the S_q system of currents flowing in the E-layer. The same geomagnetic distortion is identified as one main reason why f_0E is not a unique function of cos χ under comparable conditions. For example, at a solstice noon, the maximum value of f_0E does not occur at the sub-solar point, but on the equatorial side of it. This and other phenomena suggest that, quite generally, the motor effect of the S_q current is to raise f_0E in low latitudes, and reduce it in high latitudes, with reference to its basic value produced by solar radiation.

Simple theory suggests that, in the E-layer, N_m should be, substantially, proportional to $(\cos \chi)^{1/2}$ at all times when N_m is not changing too rapidly, as is the case over the greater part of the hours of daylight. Experimental evidence, however, shows that for the diurnal variation at constant latitude, and also for a latitude variation at constant time (such as noon), N_m varies approximately at $(\cos \chi)^{2/3}$. This and other anomalies, such as the considerable variation of f_0E at constant χ, and the anomalous asymmetry observed at low cos χ, are also discussed.

A

ASHOUR, A. A., and V. C. A. Ferraro. The Induction of electric currents in an anisotropic ionosphere with a belt of high conductivity running along the equator. J. Atmos. Terrest. Phys. 26, 509-523 (1964).

In this paper we consider the currents induced in an aniostropic ionospheric shell with a belt of high conductivity running parallel to the equator by sudden external field changes; but we have ignored the difference in conductivity between the day and night hemisphere in a first essay of the subject. We find that the screening effect, which slows down the resulting field changes observed at the surface, is most pronounced over the equatorial belt. Because of this, soon after the external field is set up there will be a greater concentration of current running along this equatorial belt and this will cause the observed field changes at first to be directed oppositely to the direction of the inducing field. Thereafter the observed field will slowly rise to the undisturbed value of the external field as limit. The slowing down over the equatorial regions may also be so pronounced that it it is possible that the resulting field change might not be recognized as a

sudden commencement; the occurrence of sudden commencements over this region may thus be comparatively less frequent and there is a slight indication of this in the records. It is difficult to decide, however, whether the unexpected, preliminary reversal of the field changes can offer a possible explanation of those sudden commencements of magnetic storm which are preceded by a small preliminary impulse opposite to the main impulse. The magnitude of the effect derived here is too small to be of interest.

The anisotropy of the ionosphere will be shown to modify only that part of the inducing field which is asymmetrical with respect to the geomagnetic axis. In this case this asymmetrical part will appear to rotate about the geomagnetic axis from west to east at a rate depending on the Hall conductivity. In cases of geomagnetic interest the asymmetrical part of the field seems likely to be relatively small; McNish (1934), has shown from an analysis of sudden commencements at Watheroo that the direction of the average vector in a sudden commencement is very nearly opposite to that of the main impulse, and that it lies practically in the plane through the magnetic axis and the station. Nevertheless, as Ferris and Price (1962) have shown, under certain conditions this effect may cause an enhancement of the field instead of a screening. This remarkable resonance property of the anisotropic ionosphere may have important geophysical applications.

AUKLAND, M. F. Plasma physics and magnetohydrodynamics. ASTIA Report Bibliography, Headquarter ASTIA, Arlington, Virginia (March 1962). AD-271 170.

This bibliography was prepared by ASTIA in response to requests for information concerning both general and specific aspects of plasma physics and magnetohydrodynamics. The citations presented cover the period from 1953 to early 1962 which coincides with the period of greatest development in these fields of research. Although many references may be related to more than one category established, they appear only once in the bibliography under the subject area best indicated in the report. In addition to the general references on theory, analysis and instrumentation, entries have been included which cover the specific subject areas of electron-ion collisions, electromagnetic waves, gas ionization, magnetic pinch effects, microwaves, miscellaneous, plasma jets, plasma sheaths, propellants and propulsion, oscillations, nuclear applications, re-entry aerodynamics, shock waves and shock tubes, and solar and extraterrestrial effects. A classified volume of this bibliography appears as AD-327 800. Entries are arranged alphabetically by subject and by AD number

AUTERMAN, J. L. Fading correlation bandwidth and short-term frequency stability measurements on a high-frequency transauroral path. NBS Tech. Note 165, National Bureau of Standards, Boulder, Colo. (October 1962).

Measurements of fading correlation bandwidth and of deviations of the instantaneous frequency from the average carrier frequency were made on the 4500-km auroral path from Barrow, Alaska, to Boulder, Colorado, at frequencies near 15 and 20 Mc/s.

The mean fading correlation bandwidth was found to be 4.3 kc/s. The value exceeded 90% of the time was 1.0 kc/s; the value exceeded 10% of the time was not obtainable. Generally, the bandwidth was smaller during periods of high magnetic activity or high fade rate. It also exhibited a minimum near midday.

Cumulative distributions of instantaneous frequency deviations were obtained for a variety of conditions. The distributions generally agreed with a theoretical distribution based on a narrow-band Gaussian noise model if the proper normalizing factor was used. The factor was 1.4 times the measured fade rate. Distributions were also obtained of the percent of time the frequency deviations exceeded certain values for various time durations. Several examples of each type of distribution are presented.
A

AVRETT, E. H. Particle motion in the equatorial plane of the dipole magnetic field. J. Geophys. Res. 67, 53-58 (1962).

An exact relation is derived which describes bound particle orbits in the equatorial plane of a dipole magnetic field. An exact expression is then obtained for the average angular velocity of the particle about the dipole axis. The corresponding drift velocity is compared with the usual first-order expression based on a constant local field gradient. It is shown that the first-order expression for the drift velocity can be considerably in error when the particle loops are not small compared with the mean distance from the dipole axis.
A

AWE, O. The fading of radio waves reflected from the ionosphere at oblique incidence. J. Atmos. Terrest. Phys. 21, 120-141 (1961).

The fading of radio waves reflected from the ionosphere at oblique incidence was studied by the use of pulse transmissions on frequencies near 2 Mc/s. It is found that echoes reflected from a height of about 90 km have a fading period of about 1 min. Echoes from a greater height of about 120 km, which usually appear only during or immediately after magnetic disturbances, have a shorter fading period of about 6 sec. A clear distinction between reflections from these two levels is urged for an understanding of the fading of echoes from the E-region. The spatial characteristics of the diffraction pattern on the ground were studied by the use of three spaced receivers. Possible models for the ionosphere irregularities which would explain the results are considered. It is suggested that the irregularities at heights near 90 km have the form of horizontal discs, that the irregularities near 120 km are spherical, and that the irregularities near 300 km are elongated along the direction of the earth's magnetic field, with an axial ratio of about 3 : 1.
PA

AWE, O. The fading of radio waves weakly scattered at vertical incidence from heights near 90 km. J. Atmos. Terrest. Phys. 21, 142-156 (1961).

The fading of radio waves weakly scattered at vertical incidence from heights near 90 km has been studied. Frequencies between 2 and 3 Mc/s were used. The fading rate was found to be of the order of 20 maxima per min, considerably faster than the fading rate for echoes from the normal E-region observed with the same frequency. The correlation between fading records obtained with aerials separated by about one wavelength was found to be small. The shape of the echo was found, on some occasions, to be approximately that expected for reflection from a completely rough screen. These results imply that appreciable energy is returned from directions well away from the vertical. It is shown that the fading is mainly due to random movements of the scattering elements, rather than a steady drift, and the root mean square velocity of the scatterers is found to be about 13 m sec^{-1}.
A

BAILEY, D.K. The geomagnetic nature of the F2-layer longitude-effect. Terrest. Mag. Atmos. Elec. 35-39 (1948).

The main conclusions deduced from a study of region F2 critical frequency data from Japanese and other stations are : (a) The "longitude effect" in critical frequencies extends to quite high latitudes. (b) A trough of low values of f_0F_2 exists near the magnetic equator at noon at all seasons. (c) Near the minimum of this trough, region F_2 appears to be very thick and is sometimes subdivided into 2 or more layers.
PA

BAILEY, D. K. African survey. IN: Semi-annual Report to Voice of America, NBS Rept. 7696, National Bureau of Standards, Boulder, Colo., 83 (July 1963).

In early 1963 D.K. Bailey of NBS-ICRPL, Boulder, Colorado, visited institutions and organizations in the following African countries to discuss ionospheric research and related topics.

(1) Addis Ababa, Ethiopia
Haile Selassie I University
(2) Nairobi, Kenya
The Royal College
East African Meteorological Dept.
USIS Monitoring Station
Kenya Broadcasting Corp.
(3) South Africa
(4) Ibadan, Nigeria
University of Ibadan
(5) Accra, Ghana
University of Ghana
(6) Monrovia, Liberia
Voice of America
Radio ELWA

He records research being planned and performed at these locations.
C

BAIRD, K. High multiple radio reflections from the F_2 layer of the ionosphere at Brisbane. Austral. J. Phys. 7, 165-175 (1954).

Reasons and methods of identification are given for the recognition of an independent layer at 90-100 km height. It is suggested that the ionization in this layer results from the impact of meteors on the atmosphere and that it may therefore be called the meteoric E-layer. The distinctive properties may be used to extend the use of the ionosphere for intermediate distance radiocommunication.
EEA

BAJPAI, R. R. Recording ionospheric echoes at the transmitter. Proc. Nat. Acad. Sci. India, 6, 40-48 (1936).

A simple 4 Mc./sec. transmitter arranged to give pulses was connected to a half-wave horizontal dipole placed approximately N. and S. The receiver for operating the kathode-ray tube was inductively coupled to the same aerial system. The whole is synchronised by injecting a small voltage from a 50-cycle source. The equipment was set up at Allahabad, India, and the paper gives an account of the results obtained between December, 1934, and February, 1935. Echoes from the F-layer were almost always recorded and occasionally some observed from the E-region. Investigations carried out during the course of a lunar eclipse seemed to show a definite lunar effect on the ionosphere.
PA

BAJPAI, R. R., and K. B. Mathur. Group velocity curves for radio-wave propagation in the ionosphere. Indian J. Phys. 11, 165-175 (1937).

Find group velocity becomes zero at one more point than does refractive index. It is:

$$p_0^2 = 2\,\frac{p^2 - p_h^2}{p^2 - p_L^2}$$

where p is the frequency, p_0 the no H critical frequency, p_h and p_L the gyro and longitudinal-gyro frequencies. Draws curves showing variations of group velocity for ordinary and extraordinary wave in typical cases.
M

BAJPAI, R. R., and B. D. Pant. A study of the F-region of the ionosphere. Indian J. Phys. 12, 211-222 (1938).

Measure diurnal nature of F2-layer critical frequencies. Find that sometimes ionization goes up in absence of solar radiation. Don't think contraction due to cooling will explain. Point at other inconsistencies of solar light theories. Think some other ionizing agency must be detected.
M

BAJPAI, R. R., and B. D. Pant. Further studies of F-region at Allahabad. Indian J. Phys. 13, 57-71 (1939).

Describe F-layer investigations during 1937-38 on several frequencies. Found good correlation between hour of minimum F-virtual height and

hour of maximum barometric pressure. Find F1 till about ten o'clock at night. Describe at length complex echoes they observe.
M

BAKER, W. C., and D. F. Martyn. Conductivity of the ionosphere. Nature 170, 1090-1092 (1952).

The explanation of the observed geomagnetic daily variations in terms of the dynamo theory and tidal oscillations is examined and it is concluded that all the combined regions of the ionosphere appear to have insufficient conductivity, by a factor of at least 10. Re-examination of the fundamental principles involved in the production of electric currents by tidal winds shows that there are additional sources of effective conductivity previously ignored: when the electric field, current and magnetic field are all mutually at right angles (Hall conductivity), and when currents flow parallel to the electric field and transverse to the magnetic field. Allowance for these increases the effective conductivity of the ionosphere by a factor of 12 over most of the earth, and by a factor of 29 near the magnetic equator. This supports the dynamo theory and also appears to account for the anomalously large magnetic variations at the magnetic equator. The current system should lie mainly in the region 100-150 km.
PA

BAKER, W. G., and D. F. Martyn. Electric currents in the ionosphere. I. The conductivity. Phil. Trans. Roy. Soc. 246A, 281-294 (1953).

An earlier suggestion by Martyn that the effective conductivity of the ionosphere in the dynamo theory is enhanced by polarization of the Hall current is examined in quantitative detail. General expressions are given for the conductivities of a thin ionized sheet oriented at an angle to a uniform magnetic field. The effective conductivity of such a (spherical) sheet surrounding the earth is shown to be greater than either the Pedersen or the Hall conductivities. The variation of conductivity with latitude is calculated for the ionospheric level of maximum effective conductivity. Consideration is given to the height-integrated conductivity of the actual ionosphere, and effective values deduced. It is shown that the F_2 region will move bodily under the influence of the electric field from lower regions, thereby reducing its ability to shunt the Hall polarization field.

The effective conductivity over most of the earth is found to be sufficient to satisfy Stewart's dynamo theory. In a narrow strip at the equator the conductivity is enhanced, thereby accounting for the anomalously large magnetic variations found to occur in these regions.
A

BAKER, W. G. Electric currents in the ionosphere. II. The atmospheric dynamo. Phil. Trans. Roy. Soc. 246A, 295-305 (1953).

Assuming semi-diurnal tidal air flow a solution is made of the atmospheric dynamo problem, taking account both of the direct and transverse conductivities of the ionosphere. The spherical sheet ionosphere is divided into three regions, a narrow equatorial zone, and two wide polar caps, taking appropriate constant conductivities in each region. The current system is similar in shape and phase to that derived on the assumption of uniform (direct) isotropic conductivity, but is considerably more intense than that which would be obtained without the existence of transverse (Hall) conductivity. The electric field system is very different, however, from that derived on this (isotropic) assumption. An abnormally large east-west current is found at the equator, which appears to provide the explanation of the anomalous magnetic variation in this region. Curves are given showing the distribution of the field and current components.
A

BALSLEY, B. B. Evidence of a stratified echoing region at 150 kilometers in the vicinity of the magnetic equator during daylight hours. J. Geophys. Res. 69, 1925-1929 (1964).

Radar observations made at the Jicamarca Radar Observatory near Lima, Peru, have shown evidences of a narrow, stratified echoing region which exists during daylight hours in the height range extending approximately from 140 to 170 km. This is well above the 105- to 115-km region ascribed to the equatorial electrojet. The echo power from this higher region is normally quite weak, being considerably below the normal daytime level of signals scattered from the electrojet [Bowles et al., 1963], yet it is stronger by at least 20 decibels than the echo power expected due to incoherent scatter from the ambient ionization [Bowles, 1961].

Experiments designed to investigate the properties of this region in the vicinity of 150 km were performed during the early part of May 1963.

Arguments in the preceding paragraphs demonstrate the dissimilarity between the 150-km echoing region and the region of the equatorial electrojet. There exists also the possibility that the observed echoes arise from side lobe reception from nonequatorial sporadic E, which, from geographical considerations, would occur predominantly to the north of the observatory. This possibility may be most easily discounted by the fact that when this type of interference occurs it is observable over a widely varying range delay somewhat greater than the 150-km radar range and is not restricted to the narrow region to which the subject echo is confined.

Examination of the Huancayo ionograms, Figures 3b and 4b, shows that the virtual height of the lower F region in the two ionograms at these times differ by about 10 km. Also note that the composite height of the 150-km echoing region in these two cases differ in the same direction by the same amount. This similarity holds true during all the days of investigation mentioned above.

It is tempting to postulate a casual relationship between the steep gradients existing below the F-region maximum and the echoing region at 150 km, although sufficient data have yet to be collected. Also worthy of note is the fact that the slowly fading characteristic of the stronger 150-km echoes is similar to the fading sometimes exhibited by VHF echoes received from the nighttime spread F at these latitudes. Further experiments designed to investigate the more elusive properties of this region are planned for the near future.
Excerpt

BANDYOPADHYAY, P. The early morning E2-layer and some evidence of presunrise F-layer "splitting." J. Atmos. Terrest. Phys. 16, 84-92 (1959).

Two early morning phenomena, one relating to the E2-layer cusps and ridges and the other to the F-layer traces as observed in the h-f records made at Haringhata (Calcutta), are described and discussed. The early morning E-2 layer cusps and ridges are found to be a regular sunrise feature of the ionograms. They show marked seasonal variation of character and frequency of occurrence and are most prominent in winter. The early morning F-layer records show, also in winter, a peculiar kind of "splitting" which is quite distince from regular F1-, F2-bifurcation. This F-layer "splitting" and its possible bearing on the E-layer phenomena described above are discussed. Representative ionograms of the two phenomena are given.
A

BANDYOPADHYAY, P. Electron distribution in the F-layer of the ionosphere over Haringhata (Calcutta) on quiet and disturbed days. J. Atmos. Terrest. Phys. 18, 127-134 (1960).

The paper presents the results of a study of the behavior of the F layer of the ionosphere over Haringhata (Calcutta) on quiet and disturbed days. The study is made from "mean quite F layers" and "mean disturbed F layers" constructed for this place following the method of the Cambridge

group of workers. The quiet-day results are further examined with a view to verifying the model of the coefficient of electron loss in the layer, as derived by the above workers.
MGA

BANDYOPADHYAY, P., and S. K. Chatterjee. Decay of ionization below the F-layer at night. Indian J. Phys. 35, 240-244 (May 1961).

The experimental results of Titheridge variation of the total amount of ionization below the night-time F-layer are re-examined. It is shown that it is not possible, on the basis of the above results, to discriminate between Titheridge's constant α-model and Mitra's time dependant α-model. On other physical grounds, however, it is concluded that while Titheridge's model will possibly hold in the upper part of the region studied, Mitra's model will be valid near the bottom.

BANDYOPADHYAY, P., and H . Montes. Some aspects of E_s ionization of the magnetic equatorial region. J. Geophys. Res. 68, 2453-2484 (1963).

This paper presents the results of an examination of diurnal and seasonal variation of the occurrences of three different types of sporadic E, namely, q, l, and f types, at the South American transequatorial chain of stations. Lunar influences and some correlation with geomagnetic disturbances on the occurrences are also discussed. The Huancayo ionograms are examined in some detail to study closely the E_{sq}, particularly its sudden disappearances. The Huancayo magnetograms are also examined to associate some of the observed characteristics of E_{sq} with certain distinctive features of the magnetograms.
A

BANERJEE, R. B. Studies on the sporadic E-layer. Indian J. Phys. 25, 359-374 (1951).

Attempt has been made to investigate the structure and properties of the sporadic E_s region of the ionosphere from a study of the fading of the echoes from this region. Statistical analysis shows that the echo consists of two components, one superposed on the other. One of the components is due to random scattering and the other to a steady reflection. This shows that the E_s region consists of a regularly reflecting region and a region of ion-clouds. A method for estimating the average number density of electrons in the clouds has been developed. It is found that the average

number density is below that required for totally reflecting the exploring waves. Expressions for the variation of reflection coefficient with the variation of exploring frequency has been developed for a thin and for a semi-infinite layer. (The electron distribution at the boundary is assumed to have a linear profile.) The expression shows that it is possible from the observation of reflection-characteristics to distinguish between the two cases. Hence with the help of this expression one can investigate the structure of that part of the E_s region which gives rise to the steady echo.
A

BANERJEE, S. S., and B. N. Singh. Effect of transverse magnetic field on refractive index and conductivity of ionized air. Science and Culture 4, 597-598 (April 1939).

Using a method previously described for longitudinal magnetic fields experiments are performed with a transverse magnetic field, and the results given in curves which resemble those for a longitudinal field. With the transverse field, however, the conductivity of ionized air does not always reach a maximum at the gyro-frequency, but is considerably affected by the collisional frequency and electron density of the sample.
PA

BANERJEE, S. S. and G. C. Mukerjee. Space-diversity reception and fading of short-wave signals. Nature 158, 413-414 (1946).

It is well known that fading patterns of short-wave signals as received on two or more aerials spaced a few wave-lengths apart are independent of each other; and this fact has been utilized in space-diversity reception, where the outputs from separate receivers connected to such aerials are mixed together in order to obtain a fairly constant signal level. It is generally assumed, however, that the variations of intensity of signal on a single aerial are of random nature caused by scattered waves from diffracting centres in the ionosphere.

As a preliminary to the investigation of the various modes of diversity reception within a limited space, we have recently made a large number of visual and automatic ink records of fading of short-wave signals received from All India Radio, Delhi, situated at a distance of 678.4 km. It has been

observed that there are occasions when the nature of fading of the signals rapidly changes from random variations of peaky type to a smooth and quasi-periodic nature, often accompanied by slow change of a few minutes. Observations have been made on 41, 31, 25, 19 and 16-metre bands, with vertically polarized waves, mostly during the day-time. The slow variations associated with the quasi-periodic nature of the fading suggest that purely random variation, agreeing with Rayleigh intensity distribution, may occur so long as the wave suffers single-spot reflexion in the ionosphere; but, as soon as the signal undergoes two or more reflexions, either from one ionospheric layer or from two different layers simultaneously, the fading pattern changes from random type to comparatively smooth and quasi-periodic type, with slow variations, resembling the pattern in the output of diversity receivers.

Automatic ink records of the fading pattern have been made with a 7-valve superheterodyne receiver after removing the incorporated automatic volume control system. The rectified signal from the second detector was amplified by a neon-coupled two-stage D. C. amplifier, the output of which was applied to the pen recorder with vertically moving paper, run by a self-governed electric motor. The speed of paper was maintained at 4.5 cm./min. Three typical records of fading of signals are reproduced. Fig. 1 shows the usual peaky and random variations on the 25-metre band in the morning hours due to single hop path necessitated by low ionic density. Towards the end of this diagram it will be seen that the variation tends to be less rapid, as just after that time the fading pattern changes gradually to the type shown in Fig. 2, which exhibits the delineation of the same signal received later, with quasi-periodic nature accompanied by slow variations caused by double reflexion at two different spots in the ionosphere. For the sake of comparison, a typical record of random fading of the B. B. C. (London) station is shown in Fig. 3, and it will be observed that the pattern of fading is similar to that in Fig. 1, as both the signals have presumably undergone single reflexion in the ionosphere. Thus the fading patterns shown in the above records indicate that the type of variation of intensity of signals changes as the number of reflecting spots in the ionosphere is altered.

Calculations made from the average equivalent heights of the E and F layers, and the required angle of radiation from Delhi station show that electronic concentrations of about 1.5×10^5 to 6.4×10^5 electrons per c.c. and 4.7×10^5 to 1.2×10^6 electrons per c.c. for single and double reflexions respectively would be necessary for an incoming wave of the 25-metre band. The hours of such concentration in the E-layer as observed at Calcutta agree fairly well with the occurrence of the above change in fading pattern, especially during morning hours between 0630 and 0930 hours I.S. T., during which period the rise in ionic density is very rapid. Thus the above observations are useful in explaining the principle and application of diversity reception, and also in throwing light in the direction of further development of such systems.

Excerpt

BANERJEE, S.S., and G.C. Mukerjee. Fading of short-wave radio signals and space-diversity reception. Part I. Phil. Mag. 39, 697-712 (1948).

The existence of ionized layers in the upper atmosphere (ionosphere) was proved quantitatively by Appleton and Barnett in 1925 from the observations of fading of radio signals received in an aerial situated away from the transmitter. Since that time, attention of various investigators has been drawn to the study of variation of intensity of received signals from a remote transmitter with a view to explore the conditions of the ionosphere suitable for establishing radio communications between two stations situated apart. In most of such experiments, medium waves have been employed and observations have been made either in presence of the ground wave or after its suppression. In case of short-wave transmissions, however, the variations of signal intensity have been recorded outside the reach of ground waves. The nature of variations of intensity of received signals has generally been observed to be irregular and such variations have been suggested to be due to random scattering from diffracting centres in the ionosphere by Ratcliffe and Pawsey. Variations of intensity of short-wave signals have often been found to be very quick and occasionally possessing regular characteristics. Adequate explanations, however, for the various types of fading observed during such investigations, particularly for short-wave transmissions, appear to be still very meagre.
Excerpt

BANERJEE, S.S., and R.N. Singh. Periodic or rhythmic variation of the intensity of short wave radio signals. Indian J. Phys. 22, 413-422 (1948).

The present communication contains the results of detailed study of periodic or rhythmic types of fading of radio signals which are generally observed during the sun rise and sun set hours. It has been shown by measurement of the angles of arrival of the downcoming waves that such periodic facing may occur due to interference caused by two waves reflected either from one or two different layers of the ionosphere containing required amount of electronic density, when one or both the layers have slow vertical movement, presumably due to rapid change of electronic density during the transition periods of ionization of the layers. It has been further shown that the development of slow periodic fading occurs due to the approach of maximum usable frequencies between the transmitting and receiving stations, and on such occasions the interference is caused by magneto-ionic components of reflected waves as suggested by Appleton and Beynon. The interference phenomena have been verified by recording the periodic

fading of short wave signals transmitted from Delhi on 16 to 41 metre bands at various hours of the day during different months.
A

BANERJEE, S.S., and V.D. Rajan. Long distance scattering of radio signals. J. Sci. Indus. Res. 10B, 161-164 (1951)

Observations made at Banaras of 31 m signals received from Delhi during night hours are reported. These are presumably scattered from ground objects beyond the transmitter, being twice reflected at the ionosphere at oblique incidence. The intensity is much lower than when transmitter and receiver are close together.
EEA

BANERJEE, S.S., and D.K. Banerjee. Scattering of radio waves and horizontal gradient of ionization in the ionosphere. J. Sci., Indus. Res. 12B, 277-279 (1953).

Multiple scattered signals obtained at vertical incidence with a low-power (2.5kW) pulse transmitter are discussed. The mode of propagation between ground and ionosphere is explained and illustrated. From echoes obtained on Feb. 14, 1953 the horizontal gradient of ionization in the atmosphere is determined and found to be in agreement with electronic densities measured by the Research Department of the All India Radio.
N

BANERJEE, S.S., D.K. Banerjee, and V.D. Rajan. Scattering of short wave radio signals and their bearing on the ionosphere. J. Sci. Ind. Res. 12A, 278-282 (1953).

After a review of previous work on the scattering of pulse signals, some results obtained by the authors at Banaras are considered. Observations at oblique incidence indicate that scattering can be observed on any occasion when reflected signals are absent, independently of the presence

of any E- or E_s-layer provided that sufficient power and sensitivity are available. This suggests that the scattering takes place at the ground. Scattering at vertical incidence has been observed with low power transmissions, even in the presence of the split magneto-ionic components.
EEA

BANERJEE, S.S. and D.K. Banerjee. Variation of horizontal gradient of ionization in the ionosphere. J. Sci. Indus. Res. 13B, 72-73 (1954).

Values of the horizontal gradient of ionization (difference per 10 km between critical frequencies for F_2 region at Banaras and at Delhi) in the morning and in the afternoon are presented for Oct. and Dec. 1952. Variations of the gradient show much wider range and higher average in the afternoon than they do in the morning.
N

BANNON, J., and F.W. Wood. Cause and effect in region F2 of the ionosphere. Terrest. Mag. Atmos. Elec. 51, 89-102 (1946).

For both hemispheres in the neighborhood of latitude 35° the behavior of region F2 of the ionosphere has been examined. It has been found that:

(1) There are great differences in the graphs of monthly mean noon values of maximum electron-density (N) for Washington, Wuchang, and Tokio in the north, but only small differences for Watheroo, Mount Stromlo, Wellington, and Christchurch in the south.

(2) For all stations for which data are available, midnight $\bar{N}$ is in step with the Sun, being a maximum in summer and a minimum in winter.

(3) Noon values of N correlate with values of $\bar{s}\cos^{1/2}\bar{X}$ (where $\bar{s}$ is the monthly mean Wolf sunspot-number, and $\bar{X}$ is the local zenith-angle of the Sun at noon on the 15th day of the month) to give correlation-coefficients (ρ) equal to 0.50, 0.60, and 0.25 for Mount Stromlo, Watheroo, and Washington, respectively.

(4) Midnight values of $\bar{N}$ and $\bar{s}\cos^{1/2}\bar{X}$ give values of ρ for Washington and Mount Stromlo equal to 0.85 and 0.10, respectively. On the other hand, for $\bar{N}$ and $\bar{s}\cos^2\bar{X}$, the values of ρ for the same two stations are 0.75 and 0.90, respectively. The graph of midnight $\bar{N}$ for Washington follows closely the graph of $p\bar{s}\cos^{1/2}\bar{X}$, where ρ has the value 0.4×10^4, while the graphs of midnight $\bar{N}$ for Mount Stromlo, Watheroo, and Tokio follow closely the curve of $p\bar{s}\cos^2\bar{X}$, where p equals 1×10^4, 0.6×10^4, and 0.75×10^4, respectively.

(5) Midnight values of the annual mean maximum electron-density (N_a) for Washington are linearly related to annual mean sunspot-numbers (s_a). This follows from the fact that noon values of $\overline{N}_a$ bear a linear relationship to midnight values of $\overline{N}_a$. In 1937 about 90 per cent of $\overline{N}_a$ for Washington was due to sunspots.

(6) The noon values of monthly mean equivalent heights show very great seasonal fluctuations. The midnight values are comparatively steady.

(7) In the Northern Hemisphere the graph of $\bar{s} \cos^{1/2} \overline{X}$ for the period 1934-40 is, for the most part, in step with the Sun, whereas in the Southern Hemisphere it shows no relation to solar altitude.

It has been concluded that:

(a) There is a variation, in the composition of region F2, from place to place over the Earth's surface.

(b) The annual effect found by Berkner and Wells may be due to the variation in composition of region F2, and to the differences in $\bar{s} \cos^{1/2} \overline{X}$ in the two hemispheres.

(c) The annual effect has not a sidereal cause.

(d) As far as annual mean values of maximum electron-density are concerned, the transition from noon to midnight is not influenced by the number of sunspots.

(e) If the thermal-expansion hypothesis is correct, midnight temperatures are probably low, and do not vary much throughout the year. Summer-noon temperatures are very much higher than temperatures at midnight.

A

BANSAL, T. D. Ionospheric height at Allahabad. Techn. Phys., USSR 3, 111-134 (1936). (In English.)

This deals with an investigation by R. R. Bajpai (1936), but the results are recorded in more detail and largely in graphical form. A Bibliography of over 40 references is given at the end of the paper.

PA

BARAL, S. S. and S. N. Mitra. Effect of solar eclipse on the ionosphere. Sci. Culture, 10 175-176 (1944).

A series of ionospheric measurements were made with the ionosphere apparatus at the University College of Science, Calcutta (lat. 22° 33' N,

long. 88° 22' E) during the solar eclipse of July 20, 1944. The eclipse, as observed at Calcutta, was a partial one. At the instant of maximum obscurity 87.5% of the sun's disc was covered. Variations of the penetration frequencies of Regions-E and F_2 were made with the progress of the eclipse. The measurements were started one hour before the commencement of the eclipse and were continued at intervals of about 20 minutes up to one hour after the eclipse was over; the observations were made more frequently about the middle of the eclipse. Observations were also made 3 days before and 3 days after the eclipse during the same local hours to check the average condition of the ionosphere.

The variation of ionization of both the regions was found to be quite normal on the control days. On the day of the eclipse, during the hours preceding the start of the eclipse the ionization of Region-E was found to be slightly less and that of Region-F_2 slightly greater than the average ionization as recorded from the control observations. With the progress of the eclipse, however, the ionization of both the regions fell below the normal values. For Region-E the ionization decreased smoothly and the minimum was attained 10 minutes after the eclipse maximum. The minimum of ionization was about 43% below the normal value. For Region-F_2 the maximum decrease observed was 30% and it occurred 14 minutes after the eclipse had reached its maximum.

Fig. 1 depicts the sharp minimum in the ionization of Region-E. For the case of Region-F_2 (Fig. 2) however, the minimum is not as marked as in the case of the Region-E, though the ionization is found to be depressed appreciably below the normal value during the eclipse period.
A

BARAL, S.S. Studies on the ionosphere at Calcutta. J. Sci. Indus. Res. 7, 59-70 (1948).

The results of normal incidence ionospheric measurements made at Calcutta during Aug. 1944, Aug. 1947, are plotted as monthly mean hourly values. Some data on sporadic E-reflections are also given.
PA

BARAL, S.S., S.N. Ghosh, and M. Debray. Abnormalities in the F-region of the ionosphere at Calcutta. Nature 161, 24 (1948).

During January, 1947, a month of maximum sunspot activity, the electron density as observed at Calcutta and Madras maintained its high noon value until late in the evening, instead of falling during the afternoon, as was observed at Delhi and at Slough. The difference in magnetic dip values at Calcutta and Delhi is pointed out.
PA

BARAL, S.S. and A.P. Mitra. Ionosphere over Calcutta. J. Atmospheric Terrest. Phys. 1, 95-105 (1950).

Ionospheric records made at Calcutta during the solar half cycle January 1945 to June 1950 have been analyzed with a view to determine the values of the following ionospheric parameters: (1) rate of electron production, (2) temperature (3) effective coefficient of recombination. The value of the terrestrial magnetic field at the average height of region F2 has also been determined. The following are the results obtained:

(1) For Region F2 the rate of electron production is highest after sunrise and before sunset and lowest during midday ($400/cm^3/sec$ after sunrise and before sunset, and $60/cm^3/sec$ during midday). The same is also true to a lesser extent for Region E. Exceptions to these types of variation occur only during winter (specially during the period of low solar activity) when the rate is more nearly normal.

(2) The seasonal variation in temperature is most marked for region F2 (varies from 700° K in winter to 1200° K in summer during high solar activity and from 500° K in winter to 900° K in summer during low solar activity). It is shown that the total variation is not due entirely to the direct heating effect of the sun, but partly to the presence of a rising temperature gradient in the F2 layer and the transport of the F2 layer as a whole from a lower to a higher region.

(3) The effective coefficient of recombination undergoes seasonal and diurnal variation for both E and F2 regions. For Region E, the variation depends only on temperature: for Region F2 on temperature and on pressure. Representative values of the coefficient are 1.5×10^{-10} cm^3/sec in winter and 6×10^{-11} cm^3/sec in summer for Region F2 and 2×10^{-9} cm^3/sec in winter and 1×10^{-9} cm^3/sec in summer for Region E.

(4) The value of the magnetic field at the average height of Region F2 agrees with that expected from the inverse cube law (0.36 Gauss). The magnetic field also shows a seasonal variation.

Graphs showing the variations of the different quantities studied are given. A graph depicting the solar activity during the period (Zurich sunspot number) is also given.

A

BARAL, S.S. and A.K. Saha. Observations at Calcutta of pulses transmitted from Delhi. Indian J. Phys. 26, 521-538 (1952).

Pulses were transmitted from Delhi during November, 1950 and May-June, 1951 at 17.74 Mc/s and 21.70 Mc/s. The various modes of propagation by which the echoes could be received are critically examined. It is concluded that the received echoes correspond only to single-hop F_2-layer reflection and not to multi-hop F_2 layer or to single-hop E or F_1 transmission. Absorption of the pulses in the Delhi-Calcutta transmission path is estimated. From a statistical analysis of the fluctuations of the

received echoes, it is concluded that the echo corresponding to the lower ordinary ray was more stable than that corresponding to the upper ordinary or the "Pedersen" ray.
EEA

BARAL, S.S. Studies on sporadic E. J. Sci. Ind. Res. 11A, 290-296 (1952).

Author discusses the results of his analysis of world data, 1945-1951, available on sporadic E (Es) of which the highlights are: 1. the main source of Es ionization is the meteoric impacts. 2. Both intensity and frequency of occurrence have two maxima: (a) one near the equator and (b) another near 70° lat. The author speculates on whether or not the pronounced effect found over the geomagnetic equator has some bearing on the upper atmospheric (electro-jet) current system over Huancayo. 3. The diurnal variation of Es falls off from the equator towards the higher latitudes. 4. Of the two theories of the structure of the Es, the "thin layer" and the "ionized patch," the latter is strongly favored because of observational evidence.
N

BARAL, S.S. Lunar tidal variations in the F2 region of the ionosphere. J. Technol. 1, 175-177 (1956).

Studied lunar tidal variations at Calcutta between January 1947 and January 1953. Found fo and hp oscillations almost in phase quadrature. Calculates lunar tidal drift velocity using Martyn's theory as 1.25 km/hr.
M

BARBIER, D. Researches on the 6300 line of the night airglow. Ann. Geophys. 15, 179-217 (1959). (In French.)

A large number of observations made at the Haute-Provence and Tamanrasset observatories are discussed. Results, some of them entirely new, are given as follows: (1) Existence of a twilight phenomenon, which can be observed in the direction of the azimuth of the sun, as long as this one is no more than 28°-30° under the horizon. This could be due to radiative dissociation of O_2, whose scale height in the 250-300 km range of altitudes, must be around 70 km. During periods of solar activity, twilight emission is often very strong. (2) Electronic radiative recombination explains the intensity decrease observed at the beginning of the night. Mean height is 275 km. By comparison with ionospheric measurements, the O_2 scale comes out to be 80 km. These results are valid during the winter months only. (3) The increase of intensity during the second half of the night is associated with a propagation along the geomagnetic meridian. Its mean height is 230 km. (4) Bursts of intensity are sometimes observed, during summer at the low altitude station of Tamanrasset. In winter there are so many such bursts that the variation of intensity in Tamanrasset has a

completely different character from the variation observed at the Haute-Provence Observatory. (5) The Intensities 5557 and 6300A do not show any correlation at the Haute-Provence Observatory. It is not out of the question that bursts in Tamanrasset could have a weak counterpart on other radiations.
PA

BARBIER, D., G. Weill, J. Daguillon, and J. Marsan. Emission of the red line from the night sky in the inter-tropical zone. Compt. Rend. 252, 304-305 (1961). (In French).

Routine observations made during the IGY at Tamanrassat (22° 47'N lat.) showed that the behaviour of the O I emission at 6300 A is quite dissimilar to that found in temperate zones. In particular, the presence of sub-visual arcs following approximately a parallel of geographic latitude was established. For example, a northerly arc was observed at heights between 200 and 400 km, its location varying between 16° and 22° N lat. A similar arc was observed at a location south of the equator from an aircraft, although its features were less clearly delineated. Between the first and second halves of the night it was seen to move from 15° to 7° S lat. Throughout the inter-tropical zones, sub-visual auroral arcs were detected also in O I emission at 5577A.
PA

BARGHAUSEN, A. F., D. A. Lillie, and E. Stiltner. Equatorial ionosphere propagation experiment. Part A. Proposed experiment and theoretical predictions. IN: Semi-annual Report to Voice of America, NBS Rept. 7621, National Bureau of Standards, Boulder, Colo., 78 (Dec. 1962).

The object of this report is to delineate an experimental program which deals with a study of ionosphere propagation irregularities and their effects on communication systems operating near the magnetic equator. This program is sponsored jointly by the National Bureau of Standards and the United States Information Agency.

The report is divided into two parts. The first part, presented here, deals with the planning of the experiment and the theoretical predictions of the expected results. The second part, to be prepared at the conclusion of the field experiment, will compare the predictions with the actual measurements and present the results of additional studies and their related effects on communication systems in equatorial regions.
Excerpt

BARGHAUSEN, A. F., D. A. Lillie, and E. Stiltner. Equatorial ionosphere propagation experiment. Part B. Preliminary results. IN: Semi-annual Report to Voice of America, NBS Rept. 7621, National Bureau of Standards, Boulder, Colo., 98 (Dec. 1962).

Recordings of phase and field strength began at Accra, Ghana on October 22, 1962 of C-W transmissions from Monrovia, Liberia on 10.1018 Mc/s and 20.2036 Mc/s. From October 22 to October 31 flutter fading

occurred on the 28th, 29th and 31st. Since this short recording period may not be representative of the entire autumnal equinox a detailed examination was made of field strength and fade rate records which were taken by the University of Ghana on 15.07 Mc/s BBC transmissions from London. These records indicate that flutter fading occurred on only six days during the period from September 26, 1962 to October 31, 1962. Five of the six days on which high speed fading was evident occurred between October 23 and October 29.

BARGHAUSEN, A.F. and D.A. Lillie. A study of radio propagation characteristics in the equatorial ionosphere. IN: Semi-annual Report to Voice of America, NBS Rept. 7696, National Bureau of Standards, Boulder, Colo., 797 (July 1963).

This report constitutes a summary of all of the applied research efforts under Project 82425, USIA Area Investigations, for the period January-June, 1963.

All research work reported is based on experimental results obtained from measurements over two paths parallel to the magnetic dip equator. The paths extended in an east and west direction from a central transmitting facility in Monrovia, Liberia to receiving locations in Accra, Ghana and Natal, Brazil. The distances to the receiving terminals in Accra and Natal are 1175 kilometers and 2990 kilometers respectively. All locations are very close to the magnetic dip equator, each being selected on this basis and the availability of local personnel to operate and maintain the equipment. Continuous wave transmissions on frequencies of 10.1018 Mc/s and 20.2036 Mc/s were obtained on a 24 hour per day basis.

Continuous records of the Doppler frequency shift were taken by the method described by Watts and Davies (1960) as well as the amplitude variations of the received carrier envelope. For the Accra path the 20.2036 Mc/s frequency is above the predicted maximum usable frequency (MUF) and was present for only short periods and during severe ionospheric disturbances which normally occurred during the evening hours.

It was the original intent of this report to include data from the transmission path to Zaria, Nigeria. Such a path would have been most valuable to this study since it is considered ideal in distance from the Monrovia location (2100 km) with respect to the magnetic dip equator and to the principle service area of interest to VOA in continental Africa. However, due to unfortunate delays, measurements will not be available until after July 1963.

A map of the transmission paths for this experiment is shown in Fig. 1. The other indicated locations are planned for operation during the 1963 autumnal equinox. For part of the tests reported, dipole antennas were used at the transmitting location mounted one-half wave-length above the ground, and the transmitted power was 1 kw. In order to reduce the interference effects to other co-channel and adjacent channel stations and to increase the signal-to-noise ratio at the receiving locations, four 3-element Yagi antennas have been installed at the Monrovia transmitting terminal.

Two antennas are used on each frequency, oriented in an east and west direction, and fed from a coaxial power divider network, which enables 1 kw to be rad ted in each direction with a transmitter output power of 2 kw. Excerpt

BARGHAUSEN, A. F., G. Jacobs, and D. A. Lillie. HF propagation characteristics in equatorial latitudes. Program and Digest, 1963 PTGAP International Symposium, Boulder, Colo., 37 (9 July 1963).

During the period immediately following the autumnal equinox of 1962, the Ionosphere Research Section of the Ionosphere Research and Propagation Division, National Bureau of Standards, under part sponsorship by the United States Information Agency, Voice of America, conducted a series of experiments to study propagation characteristics of high frequency waves over paths parallel to the magnetic equator.

The transmission paths for this study extended east and west from a central transmitting facility in Monrovia, Liberia, to receiving locations in Accra, Ghana, and Natal, Brazil. The distances to the receiving terminals in Accra and Natal are 1175 kilometers and 2990 kilometers respectively. All locations are very close to the magnetic dip equator, each being selected on this basis, and the availability of local personnel to operate and maintain the equipment. Continuous wave transmissions on frequencies of 10.1018 Mc/s and 20.2036 Mc/s were made on a 24-hour per day basis.

Continuous records of the Doppler frequency shift were obtained by the method described by Watts and Davies, and also of the amplitude variations of the received carrier envelope. For the Accra path, the 20.2036 Mc/s frequency is above the predicted median maximum usable frequency (MUF), was present for only short periods, and during severe ionospheric turbulence which normally occurred during the evening hours.
Excerpt

BARGHAUSEN, A. F. Medium frequency propagation in equatorial latitudes. IN: Semi-annual Report to Voice of America, NBS Rept. 8226, National Burearu of Standards, Boulder, Colo., 7 (March 1964).

During the past few years additional interest has been shown in medium frequency broadcasting in tropical and equatorial latitudes, prompted by the establishment of many new independent nations on the African continent. It is generally regarded that medium frequency broadcasting is the most effective means of communicating to a limited area where other more sophisticated techniques, such as FM or television, are impractical. In comparing high frequency versus medium frequency broadcasting the principal advantage of MF in the limited area case is the presence of a reliable, nonfading ground wave signal. However, for unlimited areas, HF

broadcasting is far superior in its sky wave coverage but MF does have a sky wave coverage potential to a vastly larger area than its corresponding ground wave signal.
Excerpt

BARGHAUSEN, A. F., T. M. Georges and D. A. Lillie. A study of high frequency radio wave propagation via the equatorial ionosphere. IN: Semi-annual Report to Voice of America, NBS Rept. 8226, National Bureau of Standards, Boulder, Colo., 37 (March 1964).

This report constitutes a summary of the applied research under project 82425, entitled USIA Area Investigations, for the period July 1963 to March 1964. This same project is sponsored in part by NBS under project 82122 entitled Africa Ionosphere Studies.

Beginning in 1961, the area studies have been concentrated on the equatorial ionosphere in Africa. This area was selected because of the continuing interest of the USIA in Africa and the recent establishment of the Voice of America relay base at Monrovia, Liberia.

The first full scale experimental investigations were conducted between Tripoli, Libya, and Accra, Ghana. In this report the results of these initial measurements, reported in NBS Report 7276, are compared to those obtained by subsequent experiments.

Beginning in the fall of 1962 a semi-permanent transmitting facility was established in Monrovia, Liberia, at the Sudan Interior Mission ELWA broadcasting facility. With this installation a continuous measurement program of various long term ionospheric variations was started and has continued throughout 1963. Therefore, a full year of propagation information in the high frequency band is available for analysis and several long term studies are included in this report.

At various times special short term propagation experiments were performed to supplement the regular long-term observations. Since the period of greatest activity for certain disturbed ionosphere events occurs during the autumnal equinox, the short-term experiments were performed at that time.

In September 1963, two receiving locations were established at Fort Lamy, Chad, and Rota, Spain, for special experiments. The main objective for selecting the receiving sites at these locations was to obtain simultaneous information on the propagation characteristics of high frequency radio waves on paths parallel and perpendicular to the magnetic dip equator. The Accra, Ghana, site, established in 1962, remained in operation, and recordings at the Natal, Brazil, site were temporarily interrupted to utilize its equipment at the Rota, Spain, site.
Excerpt

BARTFLS, J. Conclusions about the ionosphere from the analysis of solar and lunar diurnal earth magnetic variations. Z. fur Geophysik 12, 368-378 (1936). (In German.)

From the daily periodic earth magnetic variations, one can draw conclusions about the ionization and movement in the ionosphere. Lunar diurnal variations (L) are especially suited for that, because their original is physically simpler than that of the solar diurnal variations. The observed relationship of intensity of L to S makes it probable that in the layers under the ionosphere not such great diurnal temperature fluctuations occur as is sometimes supposed. For 12-year observations of horizontal intensity in Huancayo, Peru, L and S are reported and discussed in preliminary form in their dependence on season, sun spots, and earth magnetic disturbance. The lunar variation (L) in the southern hemisphere, summer, at this station is the greatest found up to now for any observatory, even according to its absolute magnitude as well as in comparison to solar variation S; for this reason it is especially suitable for further analysis.
C

BARTELS, J. and H. F. Johnston. Main features of daily magnetic variations at Sitka, Cheltenham, Tucson, San Juan, Honolulu, Huancayo, and Watheroo. Terrest, Mag. Atmos. Elec. 44, 455-469 (1939).

Uniform sets of graphs are given expressing the average daily magnetic variations at seven observatories as influenced by season, sunspot-cycle, and magnetic activity. The effect of disturbance on the daily mean values of the magnetic elements is discussed. International disturbed days are shown to be more disturbed around Greenwich noon than during the rest of the day. This second-order effect must be considered in studies of the disturbance-field.
A

BARTELS, J. and H. F. Johnston. Geomagnetic tides in horizontal intensity at Huancayo. J. Geophys. Res. 45, 269-308 (1940).

After an introductory survey of the main features of the solar and lunar daily variations, S and L, in horizontal intensity, H, in January at Huancayo, days with conspicuous lunar influences, geomagnetic tides, are discussed. A separation of S and L on such "big-L-days" is attempted. Daily ranges A in H are then introduced for the study of the intensity of S and thereby of the solar wave-radiation W. Up to international character figures C = 1.1A is found independent of changes in the solar corpuscular radiation P. Various methods for studying L are compared. Lunar semi-monthly waves in the

ranges A are computed and discussed in their change with season and sunspot cycle. In the months November to March, when L is larger than in the rest of the year, L and S increase in their effects on A proportionally to each other from sunspot minimum to sunspot maximum, but around June, when L is small, it does not participate in the change of S with the sunspot cycle. The day-to-day variability of S and L is studied in some detail; S and L fluctuate rather independently of each other, and the relative fluctuations of L seem to be greater than th e of S. The elimination of the lunar effect A_L is described; $(A - A_L) = A_S$ is proposed as a measure for W.
PA

BARTELS, J., N. H. Heck, and H. F. Johnston. Geomagnetic 3 hr.-range indices for 1938 and 1939. Terrest. Mag. Atmos. Elec. 46, 309-337 (1940).

The paper gives 3 hr.-range indices K for 7 observatories for July 1, 1938, to December 31, 1939, world-wide 3 hr.-range indices K_W for 1938 and 1939 and, based on K_W, daily indices B, and monthly frequencies and averages. It is shown how the indices K are standardized by means of keys for transforming K into reduced indices K_r. The worldwide K_W is introduced as an average of the reduced indices K_r, in which the K_r from polar stations enter with higher weight than the K_r from equatorial stations. K_W is proposed as a measure of the intensity P of solar corpuscular radiation.
PA

BARTELS, J. Geomagnetic data on variations of solar radiation: Part I wave-radiation. Terrest. Mag. Atmos. Elec. 51, 181-242 (1946).

From geomagnetic observations, the time-variations of two kinds of solar radiations can be deduced—a wave-radiation, W, and a particle-radiation, P. This paper, one of a series, derives and discusses homogeneous time-series for W and P; these data, in addition to their meaning for geomagnetism and solar physics, may serve as numerical basis for studies on other solar influences in geophysical or biological phenomena. Daily values δW_2 for the deviations of W from a normal value are inferred from suitably defined ranges of the solar diurnal-magnetic variation of the horizontal intensity at the Huancayo (Peru) Observatory of the Carnegie Institution of Washington, for March, 1922, to December, 1937. Averages for eighths and for three-eighths (= about ten days) of solar rotations are computed, also "smoothed decade-deviations" showing the quasi-persistent periodicities expressing the 27-day recurrence-tendency due to solar rotation. Monthly averages δW_1 are extended to include October, 1939. Comparable tables are derived for solar activity R (from Zurich relative

sunspot-numbers R) and for particle-radiation P (from data for geomagnetic disturbance). The correlations between R and W in "slow" variations (expressed in monthly, quarterly, and annual means) are the closest found so far between solar and terrestrial phenomena, surpassing even those found between R and P.

The influence, on W and P, of changes in R in the course of solar rotations ("fast" variations) is studied by methods of correlation and by the superposed-epoch method. Systematic features affecting the results of both methods are demonstrated; the relative exaggeration of the main selected pulse is recognized, explained, and illustrated in a statistical model. Several statistical experiments agree that—except near sunspot-minimum—the fast variations of R are accompanied by similar variations of W, lagging by not more than about one day. Again, the statistical relation between R and P in the fast variations is found much weaker than that between R and W. Quantitatively, the relative effect of R on W in the fast variations is computed to be about 30 percent smaller than in the slow variations, but reasons are given which interpret this result as compatible with the view that the relation between R and W in slow and fast variations does not differ essentially. The 27-day recurrence-tendency in W is just as strong as in R; there is an indication that the effect of a spot-group on W increases with its age, if equal sunspot-numbers are compared. The physical meaning of W is discussed; W is probably a solar radiation absorbed rather low in the ionosphere, in or near the same layer which is ionized by the excessive ultra-violet emitted by a solar eruption. A program for the systematic extraction of W from geomagnetic records is outlined.
A

BARTELS, J. L(fF_2) at Huancayo. Ber. dtsch. Wetterdienst 12 (Bad Kissingen - U.S. Zone, 1949).

No abstract available.

BARTELS, J. 27-day variations in F_2 layer critical frequencies at Huancayo. J Atmospheric Terrest. Phys. 1, 2-12 (1950).

The solar radiation responsible for the production of F_2 layer ionization is already known to change with the 11-year sunspot cycle. The question has therefore been examined whether analogous changes occur in the course of the solar rotation of about 27 days period in cases where the sunspot numbers R show appreciable quasi-persistent periodicities. After correcting for lunar tidal influence, variations of the type in question have been found in the noon values of fF_2 for Huancayo, Peru, using the superposed epoch method. Such variations are found to be of the order of

6 to 10%. Changes in fF_2 accompanying changes in R appear to be delayed by about two days, but a scatter analysis by means of synchronized harmonic dials throws doubt on the statistical significance of such a lag. The lunar tides in the noon values of fF_2, examined for comparison, cause total semi-mensual changes of more than 10% in southern summer, but only 2 to 3% in southern winter. These seasonal changes in the lunar tidal effect L(fF2) are much larger than those disclosed in the quantitative effects of changes of R of fF_2. The use of these results in ionospheric forecasting is briefly discussed.
A

BATEMAN, R., J. W. Herbstreit, and R. B. Zechiel. Measurement of factors affecting radio communication and Loran nagivation in SWPA. Rept. ORB-2-4 Operational Research Staff, Office of the Chief Signal Officer, Washington, D. C. (Dec. 1944).

Measurements made in SWPA of the absorption of radio waves due to dense jungle growth are described. The intensity of atmospheric noise level measured in Australia and New Guinea and its effect on radio communication and Loran navigation is reported. It is found that jungle attenuation in New Guinea is somewhat less than that previously measured for Panama jungles. Nevertheless, the measurements show that the methods for obtaining jungle communication as determined in the Panama investigation must be employed in SWPA. The atmospheric noise level in the SWPA was found to be considerably lower than predicted for that area in existing noise charts. The peak pulse field intensity for Loran navigation in the presence of atmospheric noise was found to be approximately that required for radiotelephone communication; however, at least for a large part of the year, atmospheric noise should not be an important factor as regards Loran operations in that area because of limitations due to multipath transmissions.

This report describes the principal engineering tests and measurements made by a small party of Signal Corps personnel which was dispatched to the SWPA for the purpose of investigating some of the factors which affect radio communication and radio navigation in that theater. Much of the work carried out by this party in Australia and New Guinea was coordinated with the Radio Physics Laboratory of the Council for Scientific and Industrial Research located at Sydney, N.S.W. Special test equipment for the Loran measurements was constructed at the Radiophysics Laboratory with the

guidance and help of Radio Physics personnel. The results of measurements made are discussed under three headings as follows:

(a) Measurements of jungle attenuation.

(b) Measurements of atmospheric noise level in SWPA.

(c) Measurements on the required ratio of signal to atmospheric noise for Loran navigation.

Field engineering measurements of the absorption of radio waves by dense jungle growth were made in the jungles of Panama and reported in Operational Research Branch Report No. ORB-2-3-, "Measurement of Factors Affecting Jungle Radio Communications." The results of these measurements and recommendations for obtaining communications under difficult jungle conditions were widely distributed to the Army in the field in a Technical Bulletin TB-Sig 4, "Methods for Improving the Effectiveness of Jungle Radio Communication." The purpose of making jungle measurements in New Guinea was to determine whether the Panama findings and recommendations were applicable to the New Guinea jungles.

Measurements of the average atmospheric noise level were made in Australia and New Guinea. Such information is of value for making predictions of the performance of radio equipment under various conditions of operations. In the past, atmospheric noise (static) data used in predicting the performance of radio equipment in these areas have been based largely on a knowledge of the distribution of thunderstorms and radio wave propagation considerations rather than actual measurements of the existing noise level.

Tests were made to determine the required ratio of signal to atmospheric noise for the Loran system of navigation. This information when correlated with the existing atmospheric noise level and other data gives a basis for estimating the effect of atmospheric noise on the range and performance of Loran in the SWPA.

BATEMAN, R., J. W. Finney, E. K. Smith, L. H. Tveten, and J. M. Watts. IGY observations of F-layer scatter in the Far East. J. Geophys. Res. 64, 403-405 (1959).

Peculiar signal enhancements observed during transmissions at 36 to 50 Mc/s between the Philippines and Okinawa appear to represent F-layer scatter. These signals are observed nightly for periods of several hours during the months of September and October. Pulse tests indicate F-layer heights for these signals. Considerable pulse broadening is observed and the signals generally arrive from somewhat off the great circle path.
A

BAUER, S. J. Inferred temperature variations at the F_2 peak. J. Geophys. Res. 65, 1685-1690 (June 1960).

Information on the ionospheric electron content deduced from the Faraday rotation of lunar radio reflections and ionospheric data obtained by vertical-incidence soundings are used to infer scale heights at the F_2 peak. The scale height is found to exhibit pronounced time variations that are interpreted as variations in the temperature in the F_2 peak. The average values of inferred scale heights at the F_2 peak are compared with scale heights of a model atmosphere based on recent rocket and satellite data and are found to lie within ±15 percent of the model values. One exception to this finding occurred on a day following a magnetic storm: on this day, the scale height was more than 30 percent higher than the model value. This difference suggests the possibility of a pronounced increase in ionosphere heating at such times.

A

BAZZARD, G. H. and C. M. Minnis. The geographical distribution of the harmonics of the annual variation in the critical frequency of the F2-layer at noon. J. Atmospheric Terrest. Phys. 22, 192-199 (1961).

At any location, the monthly median critical frequency of the F2-layer at noon can be represented by $f_{F2} = p(\theta) + q(\theta)I_{F2}$, in which $p(\theta)$ and $q(\theta)$ are oscillating functions which have a fundamental period of 1 year, and I_{F2} is an index of solar activity. The amplitudes of the first and second harmonics of $p(\theta)$ and $q(\theta)$ have been evaluated at sixty-one locations and contour maps of these and of the constant term have been drawn. The phase of the first harmonic does not reverse at the equator as might be expected on simple theory. The phase of the second harmonic is the same over the whole world except for a narrow range of latitudes. This is in accordance with simple theory, but the amplitude of the second harmonic is greater than expected. The contours of the constant term follow those of constant dip angle more closely than do those of f_{F2}.

A

BEAGLEY, J. W. Ionosphere research. IN: Simpson, F. A., ed., The Antarctic Today, 279-293 (Reed, Wellington, New Zealand, 1952).

A survey of the research which has been and is being done in New Zealand and the neighboring Antarctic regions in an attempt to solve the fundamental problems of ionospheric research. First proof of the Kennelly-Heaviside layer is said to have been made by Appleton and Barnett (a New Zealander) in 1924. The places where research on ionospheric wave propagation is carried on are listed and the work described (Christchurch, Raoul Island in Kermadec Group, Campbell Island, Pitcairn Island, Rarotonga, Fiji). Plates show the layout of the weather station on Marion Island.
N

BECKEN, J., and B. Maehlum. Drift measurements at Kjeller on the ionospheric F region. J. Geophys. Res. 65, 1485-1488 (1960).

Summarize results of measurement of F2-layer drift using closely spaced receiver method. Find velocities from 50 to 150 m/s. At high latitudes, drift velocity correlates positively with magnetic activity but near equator correlation is negative. At high latitudes drift is easterly near noon and westerly near midnight. Near equator drift reverses. Find irregularities in F2-amplitude pattern slightly elongated in NNW direction. Mean axis ratio of correlation ellipse is about 1.9.
M

BECKER, W. New methods and some results concerning true ionospheric height calculations. J. Atmosheric Terrest. Phys. 16, 67-83 (1959).

The methods can be listed as follows:

(a) Optical-graphical comparison method, comparing, for certain layer-types, calculated ordinary and extraordinary h'(f)-traces with observed h'(f)-records. It is possible to determine the best fitting layer-type and its parameters within 8 min.

(b) General method, applicable to any monotonic h'(f)-trace. This method is based on RYDBECK's solution of the respective integral equation. A 10 point h'(f)-reduction according to this method takes 2 hr.

(c) Correction method, combining the methods (a) and (b). Thus the time necessary for a 10 point h'(f)-reduction can be reduced to 5/4 hr.

The following results are reported:

(a) Good agreement between actual layer shape and parabolic N(h)-distribution for the undisturbed night-time F-layer on 8 August 1957.

(b) Periodic movements (T ~ 1 hr, amplitude ~ 8 km) of the F-layer during a magnetically undisturbed night, 7-8 August 1957.

(c) Sudden ascent of the F-layer during a "Polar Sudden Commencement" (Δh ~ 60 km) within 1/2 hour on 15-16 September 1956.

(d) Existence of an N(h)-minimum above the normal E-layer above Lindau, Germany, on 20 August 1957, 1545 hours.

A

BELMONT, A. D., and D. G. Dartt. Tropical upper air studies. Quarterly Prog. Rept. 1, 23 March - 31 Aug. 1962. General Mills Inc., Minneapolis, Minn. (1 Sept. 1962). AD-290 821.

Considerable stratospheric upper-air data have been gathered and summarizing programs have been prepared for their computer analysis. The 26-month and 12-month cycles of tropical winds have been examined for Balboa, San Juan, Canton and Kwajalein. Harmonic and spectral analyses of 50-mb data show the relative importance of these and other periods and how they vary with latitude. Time sections of the zonal wind component were prepared for the same four stations. These show the variation of the observed waves with height, time and station. The consolidated long-term annual mean wave at stations about 10 degrees from the equator was found to be somewhat sinusoidal but waves for individual years were usually far from sinusoidal. At stations near the equator where the biennial cycle of 21 to 28 months is most pronounced, the shape of the annual wave could not be determined with the length of record available due to the very strong influence of the biennial cycle.

A

BENIOFF, Hugo. Observations of geomagnetic fluctuations in the period range 0.3 to 120 seconds. J. Geophys. Res. 65, 1413-1422 (1960).

Data are presented from a 5-year series of observations of geomagnetic fluctuations in the period range 0.3 to 120 seconds, approximately. These were carried on with flux rate variographs using pickup coils with 1-second-period galvanometers recording photographically at a trace speed of 1 mm/sec with maximum sensitivities of 0.05 gamma/sec per trace millimeter. Four characteristic types of oscillations are included in this study:

Type A oscillations, approximately sinusoidal in form, range in period from 0.3 to 2.5 seconds and in southern California occur at night only. They exhibit a negative correlation with sunspot numbers. Type B oscillations are nearly sinusoidal in form with periods ranging from about 3 to 8 seconds. They appear to be associated with the local occurrence of auroras. Type C oscillations are nearly sinusoidal in shape with periods ranging from about 7 to 30 seconds. In southern California they occur in daylight and exhibit a strong correlation with sunspot numbers. Type D oscillations are transients in the form of single or multiple pulses or trains of several oscillations. The pulse breadths or oscillation periods range from about 40 to 120 seconds or more. They are strictly nocturnal in southern California with a sharp peak in the rate of occurence at local midnight.

Some characteristics of sudden-commencement components in the observed period range are mentioned briefly.

A

BEN'KOVA, N. P., and L. O. Tyurmina. The magnetic field of the equatorial current (ring). Geomag. Aeron. 2, 528-534 (1962). (Original in Russian.)

The authors have computed the latitudinal distribution of the magnetic field of the ring current on the assumption that the generatrix of the current surface has the form of a line of force of a dipole field and that the current density depends on the solar distance Ψ in a different manner. The best agreement between the computed component X and the latitudinal distribution of the D_{st} variation of the magnetic field was obtained for a ring radius of a = 9R (where R is the earth's radius) and current density of $j = j_0 (b + c \cos^2\Psi)$. The value of the magnetic moment of the current ring is $M = 4\text{-}5 . 10^{25}$ CGSM* and agrees well with the data of other authors.

A

BEN'KOVA, N. P., and K. N. Vasil'yev. The E-layer at low altitudes according to investigations on the Schooner Zarga. Geomag. and Aeronomy 3, 70-74 (1963). (Original in Russian.)

The latitudinal distribution of f_0E at all hours of the day is described on the basis of data collected by the 1959-1960 expedition. It is shown that some characteristics in the near-equatorial region (decrease in f_0E in the region of the geomagnetic equator) are more pronounced in the morning and evening and smooth out during noon hours. The diurnal variation of f_0E on individual days is described by the formula $f_0E = K \cos^n \chi$. The values of n differ systematically in the morning and evening. The morning values of n vary markedly with latitude and have a maximum at latitudes $\phi = \pm 20°$ and a minimum at the geographic equator.
A

BENNER, A. H., and H. J. Nearhoof. Polarimeter for the study of low frequency radio echoes. Rev. Sci. Instr. 21, 830-834 (Oct. 1950).

An instrument is described which allows the determination of the ellipticity, angle of tilt, and sense of rotation of low frequency radio waves returned from the ionosphere.
A

BENNINGTON, T. W. Equatorial ionospheric effects: post-sunset fading on long-distance radio circuits. Wireless World 66, 501-506 (1960).

An account is given of the discovery of the spread-F effect and the rise in the F2 layer virtual height which occurs in equatorial regions. At most places this phenomenon is observed soon after local ground sunset, and lasts for about four hours, after which conditions return to normal. It generally occurs more frequently at the equinoxes and is worse during years of high sunspot activity. It appears to be brought about by conditions in the ionosphere in a zone lying near the magnetic equator. The radio fading which occurs can be serious for some types of equipment. A detailed analysis is given of fading effects at Singapore, Johannesburg and Ibadan for various months during the years 1954 to 1958 to illustrate the main effects.
MGA

BENNINGTON, T. W. Variations in the tropical sunset fading effect over the U. K./Singapore and U. K./Johannesburg broadcast circuits. Rept. K-146, British Broadcasting Co. (1960).

Abstract not available.

BERGH, H. W., and J. W. King. Ionospheric critical frequencies and magnetic parameters of the day before. J. Atmos. Terrest. Phys. 22, 74-78 (1961).

It has recently been shown (King, 1961) that the mid-day values of f_0F2 appear to be related to the equivalent planetary daily amplitude, A_p, but that the relationship is much more definite if the A_p values of the days preceding the days on which f_0F2 were obtained are used. This time lag has been further investigated for pre-sunrise ionization using ionospheric data from Cape Town (34°08' S, 18°19' E), were used. In this way both ionization and magnetic parameters were confined to the same locality. It should be pointed out that the pre-sunrise relationship between f_0F2 and A_p is a striking negative one in summer and a positive, but less pronounced, one during the 3 month mid-winter period (King and Graham, 1961).

Fig. 1(b) shows plots of the correlation between f_0F2 for 0300 and 0500 S.A.S.T. and the sum of the K-indices for different 24 hr periods, i.e. between f_0F2 for 0300 and 0500 hours and the sum of eight consecutive K-indices starting at different times. It is apparent that greatest correlation obtains with magnetic activity which occurred during the 24 hr period ending at 2300 hours on the previous day. The curves for 0300 and 0500 hours are very similar and in Figs. 1(a), (c) and (d) the mean data for these two curves is plotted. Fig. 1(a) contains data similar to Fig. 1(b) for June 1957. The correlation is slightly positive instead of strongly negative, in accordance with the seasonal effect mentioned above, but the same conclusion is apparent, vis. the period in which the most important magnetic activity occurred was the day preceding the day on which f_0F2 was measured .

In order to determine more accurately which period of magnetic activity is most strongly related to pre-sunrise ionization the next day, Figs. 1(c) and (d) were plotted showing the correlation between f_0F2 and the K-index for 6 hr periods (i.e. the sum of two 3 hr K-indices) having various centre points. It appears that the magnetic data during most of

the previous day is important; there is a strong suggestion, however, that magnetic activity during the pre-sunrise period on the day before is most closely associated with f_0F2 on any day. Clearly magnetic activity during the pre-sunrise period on the same day is much less related to f_0F2 at that time.
Excerpt

BERGH, H. W. The time-lag between magnetic and ionospheric changes. J. Atmos. Terrest. Phys. 24, 949-953 (1962).

The above time-lag is investigated for summer months (November-February) from summer 1953/54 to summer 1960/61. It is found that the 1 day delay reported by Bergh and King (1961) is in fact only predominant during periods of high solar activity and absent during sunspot minimum. A 2 day lag seems to persist throughout the solar cycle but is overshadowed during sunspot maximum by the 1 day delay. The nocturnal behaviour of maximum electron density in F2-region is studied during a year of high solar activity in relation to the K-indices of the preceding day. A recombinative type of electron removal is found to correlate more consistently with magnetic changes than does an attachment type of removal.
A

BERKNER, L. V., and H. W. Wells. Ionosphere investigations, Huancayo magnetic observatory (Peru), 1933. Proc. IRE 22, 1102-1123 (1934).

The equipment is designed for the multi-frequency method, with manual operation. Three layers, identified with the E-, F_1-, and F_2-layers at Washington, D.C., are found. The F_1-layer appears to be formed by a separation from a general F-region during the morning rather than by direct ionisation of a separate layer. Near the maximum ionisation of the F_1- and F_2-layers are found two reflection components, which reach critical values at different frequencies. This difference corresponds very closely to that calculated for the effect of magneto-ionic double refraction due to the earth's magnetic field. A dip in the critical frequency of the F_2-layer usually occurs in the morning, which may be related to the appearance of the F_1-layer.
PA

BERKNER, L. V., and H. W. Wells. Ionosphere investigations at low latitudes. Terrest. Mag. Atmos. Elec. 39, 215-230 (1934).

Continuation of studies of the F-region at Huancayo. To represent the separation of the F_1- and F_2-layers, iso-ionic charts, showing the change of virtual height and ionisation with time, have been constructed. The maximum ionisation and lowest virtual height of the F_1-layer vary by within 5% for any particular time from day to day. The degree of separation at one location varies from day to day. It is concluded that the solar rays active in ionising the F-layer are filtered out in the lower atmosphere. The F_2-layer shows very irregular characteristics compared with the lower layers. Certain of the irregularities are found also in the data obtained at Washington. Additional stratification of the F-region is occasionally observed.
PA

BERKNER, L. V., H. W. Wells, and S. L. Seaton. Characteristics of the upper region of the ionosphere. Terrest. Mag. Atmos. Elec. 41, 173-184 (1936).

The Carnegie Institution of Washington has collected data over a period of one to six years of the critical penetration frequency and minimum virtual height of the F_2-region in the form of monthly averages of noon values at Washington, D.C., Huancayo, Peru, and Watheroo, Australia. These values have similar characteristics in both hemispheres reaching a maximum from Nov. to Feb. and a minimum from May to August. The hypothesis of thermal expansion of the upper atmosphere which has been suggested by certain investigators to account for the effects observed in the northern hemisphere alone will not explain these critical frequency phenomena observed in both hemispheres simultaneously. At Washington and Watheroo the noon minimum virtual heights change inversely with the minimum noon zenith angle of the sun, while at Huancayo they change directly with this angle. This reversal in character in equatorial regions is considered and it is suggested that these effects may be explained by a new hypothesis of thermal movement of the upper atmosphere, considering the forces imposed upon the motions of the ions in the earth's magnetic field.
PA

BERKNER, L. V., and H. W. Wells. Abnormal ionisation of the E-region of the ionosphere. Terrest. Mag. Atmos. Elec. 42, 73-76 (1937).

Abnormal ionisation of the E-region of the ionosphere occurred very infrequently at Huancayo, Peru (12° south, 75° west), during nearly 8000 hrs. of observation. At Watheroo, Western Australia (30° south, 116° east), the effect was about 70 times as pronounced during the same period.

Huancayo is on the geomagnetic equator, while Watheroo is in geomagnetic latitude about 42° south. This evidence suggests that sporadic ionisation of the E-region is a function of latitutde, or more probably of magnetic latitude. It is observed that sporadic ionisations appear most frequently during local summer at stations in the temperate zones. Nevertheless, because of the much greater prevalence of thunderstorms near Huancayo as compared to Watheroo, the suggestion that the effect is related to thunderstorms does not seem to be supported. There is some evidence that the abnormal ionisation may be related to magnetic bays and auroras which have a similar distribution with latitude and probably originate largely in the same atmospheric region.
A

BERKNER, L. V., and H. W. Wells Non-seasonal change of F2-region ion-density. Terrest. Mag. Atmos. Elec. 43, 15-36 (1938).

Observation of noon F_2-region ion-density at stations in both the Northern and Southern hemispheres show that variations in one are not predicted at the other with the hypotheses which have been advanced to explain them. Observations made at Washington by the National Bureau of Standards, and at Watheroo by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, are analyzed. It is found that a variation-component exists in the data from 1935-37 which is in the same phase at both stations. This term has a principal period which, over the period studied, is indistinguishable from one year. Its amplitude is about equal to that of the seasonal variation, maintaining a nearly constant ratio to the changing background ion-density. This non-seasonal variation is, therefore, of sufficient amplitude, if neglected, to vitiate quantitative calculations of seasonal effects based upon the observations from one hemisphere alone. While the average magnitude of the background ion-density is closely related to annual averages of solar activity, departures of the non-seasonal component from the mean show no sensible correlation with monthly sunspot-averages. The data and methods are examined to determine whether inhomogeneity of data, or methods of analysis, could induce the effect artificially. It is concluded that the amplitude of such induced errors must be small compared to the amplitude of the non-seasonal effect. Application of the heating hypothesis in its present form leads to a heating ratio more than 100 times as great at Washington as at Watheroo, which does not seem probable. Correction of the data for the non-seasonal effect leads to a heating ratio for summer to winter of about 10 to 1 for both stations. Possible causes of the non-seasonal term are considered. The paucity of data from widely separated locations through the 24 hours

limits speculation. In reviewing the implications of the data, the writers are inclined to the view that the cause is associated with the Earth or its motion, though the arguments presented on the basis of existing data are not sufficient to establish this view unequivocally.
A

BERKNER, L. V., H. W. Wells, and S. L. Seaton. Ionospheric effects associated with magnetic disturbances. J. Geophys. Res. 44, 283-311 (1939).

An extensive discussion of the behavior of the ionosphere during magnetic storms, as deduced from virtual height-frequency records. Find storms at Huancayo characterized by an initial decrease in F-layer ionization corresponding to a wiping out of the ionization from above. The virtual height of the remaining ionization is therefore less. In the second stage a highly absorbing region occurs at about 85 km. In the third stage the F-layer is wiped out from below, so that the virtual height increases tremendously, and the electron density drops off. In temperate latitudes the nature of the storm effects depends on the season, and time of day. A big discussion is given.
M

BERKNER, L. V., and S. L. Seaton. Ionospheric changes associated with the magnetic storm of March 24th, 1940. Terrest. Mag. Atmos. Elec. 45, 393-418 (1940).

Observations of the ionosphere at Huancayo and Watheroo during the magnetic disturbance of March 24, 1940, are shown and discussed. At Hyancayo the ionospheric disturbance began about 40 min. before the first large magnetic change, though coinciding with increasing magnetic activity. During the first great magnetic changes the F_2 layer was swept upward and disappeared in about 30 min. At the same time ion density of the E layer rose about 40%. Growth of a new F_2 layer began after disappearance of the old, proceeding in an apparently normal manner for the next hr. Because the original ion density had been reduced to a low value, the F_2 region is regarded as a nearly un-ionized atmosphere, suddenly exposed to solar radiation. Effective recombination coefficient and rate of ion production at level of maximum density of F_2 region are estimated from this growth. Steady growth of the new F_2 layer was followed by a succession of abnormal increases and decreases of ion density of diminishing amplitude at an almost regular period of 3 hr. for 3-1/2 or 4 periods. Abnormal rate of decrease and subsequent increase of abnormal electron production at level of maximum is computed for the first period. At Watheroo ionospheric changes followed the general pattern usually experienced during

magnetic disturbances in temperate zones. Evidence indicates large spatial tilts of iso-ionic surfaces near Watheroo about 40 min. after beginning of great magnetic changes. These spatial tilts were followed by rapid rise of height and increase of scattering. Abnormal decrease of ion density of the F_2 layer began simultaneously at both observatories, within observational limits, less than 15 min. after the first great geomagnetic change. The great rise in height at Watheroo lagged behind that at Huancayo by nearly 1 hr.
PA

BERKNER, L. V., and S. L. Seaton. Systematic ionospheric changes associated with geomagnetic activity. Terres. Mag. Atmos. Elec. 45, 419-423 (1940).

Systematic changes of max. ion density of the F_2 layer accompanying geomagnetic disturbances were investigated, using observational material from Watheroo and Huancayo collected during 1938 and 1939. Deviations from an arbitrary normal are computed. At Huancayo the max. increases continuously with magnetic activity up to (American) character-figure 2.0. At Watheroo this relation is reversed between September and April. In winter the density rises at slight or moderate magnetic activity and then falls as magnetic changes become severe.
PA

BEYNON, W. J. G., and G. M. Brown. Geomagnetic distortion of region-E. J. Atmos. Terrest. Phys. 14, 138-166 (1959).

A detailed consideration of the behaviour of the normal E-region shows the existence of minor perturbations from the classical Chapman theory. It is shown that some of these differences can be ascribed to the influence of vertical drift of ionization resulting from the interaction of the earth's magnetic field and the S_q-current system flowing in or near the E-layer. The resulting distortion of the electron density profile of the E-layer is considered, with particular reference to its effect on the values of the parameter f_0E at different latitudes. The diurnal and seasonal changes in the magnitude of the east-west component current are clearly reflected in the variations of f_0E, and an index n, measuring the sensitivity of the E-layer to seasonal changes, shows marked singularities near the latitudes of the S_q-foci.

An analysis of conditions on magnetically disturbed days is also given, and it is concluded that at temperate latitude stations there is a depression in fE at times of magnetic disturbance comparable with the magnitude of that associated with the veritical drift effect of the S_q-current system at noon in the summer. Reference is also made to conditions near and within the auroral zone. Consideration of the effect of sporadic E-ionization shows that this does not appear seriously to influence the tabulated values of fE.
A

BHAR, J. N. Effect of meteoric shower on the ionization of the upper atmosphere. Nature 139, 470-471 (1937).

Observed ionization densities during Leonid showers. Found great increase in E ionization at maximum of shower. Electron density increased by perhaps six times.
M

BHAR, J. N. Stratification of the ionosphere and the origin of the E_1 layer. Indian J. Phys. 12, 363-386 (1938).

Calculations of upper atmospheric ionisation are made after Pannekoek with certain modifications. It is assumed that the upper atmosphere above 100 km. consists mainly of N_2 and O while the lower and the middle atmosphere below this level consists of N_2 and O_2. There is a layer of transition between the two occupying the region 80-130 km. The temperature in the upper atmosphere is assumed to be 600°K and that in the transition layer 300°K. The sun is taken to be radiating like a black body at 6800°K. Calculations show that there are ionisation maxima at 250 km. due to O, at 160 km. due to N_2 and 90 km. due to O_2. These three maxima are identified with the F_2, F_1 and E_1 regions.

The most interesting point to be noted is that attempts at obtaining from theoretical considerations a layer of ionisation at the height of the E_1 region have hitherto failed. This, in fact, prompted Chapman to put forward the hypothesis that the ionisation of the F region was due to ultra-violet radiation while that of the E region was due to the bombardment of neutral corpuscles shot off from the sun. It is well-known that observations during solar eclipses prove definitely that the E_1 region ionisation is also due to solar ultra-violet radiation. The work described here thus removes

the anomaly regarding the formation of the E_1 layer. It can now be definitely asserted that the region round 100 km. in which rapid transition of O_2 to O occurs is also, as a consequence, the region of maximum ionisation of O_2 and that the ionised layer formed near this level is to be identified with the E_1 layer.

BHAR, J. N. Ionosphere at Calcutta. Indian J. Phys. 13, 253-276 (1939).

In the present paper the results of systematic ionospheric observations carried out at Calcutta (22° 33' N) during the period Jan. 1936 to April 1937, are described. The diurnal and seasonal variations of critical frequency for the E- and F-regions of the ionosphere are presented graphically and are discussed with reference to variations expected from the u.v. light theory. It is found that the observed variations of E_1-region ionization are in general agreement with the theory of Chapman particularly during winter months. During summer months, however, there are deviations due presumably to the frequent occurrence of abnormal ionization associated with thunderstorms. The observed results are utilized for estimating the coefficient of recombination in the E-region which is found to be of the order of 10^{-9} cm^3./sec. The phenomenon of abnormal E-region ionization is discussed in detail and its association with the incidence of thunderstorms investigated. The observed variations of F_2-region ionization show that the time of diurnal maximum shifts towards the afternoon in summer. There are two distinct maxima in the seasonal variation curves for the midday and the 1600 hours ionization. These seem to coalesce in the case of the 1900 hours seasonal ionization curve. The extreme day-to-day variability of the midnight ionization makes it difficult to form any idea as to the nature of its seasonal variation.
PA

BHAR, J. N. Relation between noon F2-layer ionization and magnetic dip. J. Atmos. Terrest. Phys. 10, 168-172 (1957).

Plots noon values of f_0F2 vs magnetic dip, keeping solar zenith distance fixed instead of choosing fixed epoch. Finds f_0F2 minimum at magnetic equator with maxima of noon values at 30 deg magnetic dip.
M

BHAR, J. N., and P. D. Bhowmik. A study of noon F_2 ionization in relation to geomagnetic co-ordinates. Indian J. Phys. 33, 1-17 (1959).

The relation of the F_2-layer noon critical frequency to magnetic dip and geomagnetic latitude is studied for constant values of solar zenithal angle. The constant-χ plots show two maxima situated on the two sides of the magnetic equator. An asymmetry between the northern and southern hemispheres is also revealed. For chosen values of solar zenith distance, the ratio of noon fF_2 at sunspot maximum to that at sunspot minimum is studied in relation to magnetic dip. The ratio is found to vary with magnetic dip displaying a minimum to the north of the magnetic equator.
PA

BHARGAVA, B. N. A new early-morning ionospheric phenomenon. Nature 170, 983-984 (1952).

Early in January 1952, when ionospheric observations were started at Kodaikanal (10° 14' N., 77° 28' E.), an interesting phenomenon, which, to my knowledge, has not hitherto been reported, was observed in the vertical-incidence virtual height/critical frequency records. It was found that on most of the mornings ionospheric echoes ceased to return some minutes to several hours before sunrise and reappeared at about ground sunrise time. Systematic daily observations were started early in March and h records taken at short intervals beginning about an hour before sunrise daily with the view of examining the frequency of occurrence and any possible seasonal characteristcs of this 'no echo' phenomenon.

The observations consisted in photographing the h'f patterns at 1- or 2-min. intervals with the C.R.P.L. type C-3 recorder of the Kodaikanal Observatory covering 1-25 Mc./s. and with peak pulse power of approximately 10 kW. The antenna system consisted of two multiple-wire deltas having reasonably flat impedance over the operating frequency-range and the desired vertical direction of maximum radiation. The records thus made cover a period of five months (March–July 1952) and on examination indicate that on about 60 per cent of the days during these five months ionospheric echoes ceased for some time during the pre-dawn period. The over-night stratum in the F-region present at virtual heights of 200-300 km. disappeared gradually without showing any appreciable sharp drop in critical frequency (which is of the order of 1-3 Mc./s. during early mornings). The 'no echo' condition lasted until about the ground sunrise time, when reflexions began to be received from markedly greater virtual heights of 300-500 km. Records taken at 15-min. intervals on the morning

of April 30, 1952, show that pulse returns ceased between 0500 and 0515 hr. and did not begin again until shortly before 0545 hr. (All times given in Indian Standard Time, which is 5 hr. 30 min ahead of G.M.T.)

On other mornings when ionospheric echoes were received throughout, high-speed ionospheric soundings showed remarkably characteristic sunrise effects in the F-region. Almost simultaneously with the ground sunrise, a stratum formed somewhere between 300 and 600 km. The virtual height of the new stratum decreased rapidly until it merged with the overnight layer, usually present at a virtual height of about 200-250 km. The accompanying photographs are of a sequence of h'f records obtained on one such morning; they were taken at 2-min. intervals on March 9, 1952, and illustrate the characteristic sunrise effect observed at this location.

A study of sunrise effects in the ionosphere has been made by Wells at Derwood Experimental Laboratory, D.T.M., Carnegie Institution of Washington. Sunrise effects have been defined as the initial characteristic rise of ion density in the neighbourhood of sunrise. At Kodaikanal, the abrupt appearance of echoes from relatively great virtual heights, such as shown in the records for March 9, 1952, has enabled the determination of the precise times of these effects. A study of successive h'f records at 1- or 2-min. intervals on selected days when such records were available indicates that, notwithstanding a certain amount of scatter, the sunrise effect and the ground sunrise were simultaneous during the month of March; during April, the ionospheric effect occurred 2 min. after the ground sunrise, and during May, June and July it occurred 3-1/2 min., 6 min. and 5 min. respectively before the ground sunrise.
Excerpt

BHARGAVA, B. N. Observations of spread echoes from the F layer over Kodaikanal: a preliminary study. Indian J. Meterol. Geophys. 9, 35-40 (1958).

Occurrence of spread F echoes at Kodaikanal for a period of about one year has been analyzed and diurnal and seasonal characteristics have been found to exist in the frequency of occurrence of these echoes. It has been found that the phenomenon occurs only during nighttime with largest frequency between 1900 and 1400 hrs local time. While the seasonal variation is characterized by equinoctial maxima as in the case of geomagnetic activity, the day-to-day variations in scattering indicate a negative correlation with the degree of magnetic activity. Thus scattering persists for largest percentage of time during comparatively quiet periods and is often altogether absent on magnetically stormy nights. The phenomenon is discussed in relation to ionospheric irregularities and radio-star scintillation.
N

BHARGAVA, B. N. Annual wave in the world-wide F-region ionization. Indian J. Meteorol. Geophys. 10, 69-72 (1959).

An analysis of squares of noon median F2 layer critical frequencies for a 3-year period has been made in order to derive the latitude variation of the annual effect in the electron densities and its relation to average F2 layer ionization. The results indicate that the annual component R 1 varies with the latitutde in a manner very nearly similar to that of the steady ionization R 0 and that for a given value of R 0 for any latitude, R 1 can be derived approximately from a linear relationship of the type R 1 = 0.3 R 0 - 4.5. A similar analysis of 9-year data for precise phase and amplitude of the annual component for a pair of stations yields a value of R 1, which is of the same order of magnitude as R 0 and which attains a maximum around the epoch of minimum sun-earth distance.
N

BHARGAVA, B. N., and U. V. Gopala Rao. Ionospheric disturbances associated with magnetic storms at Kodaikanal. Indian J. Meteorol. Geophys. 10, 203-208 (1959).

F2 layer disturbances at Kodaikanal have been analyzed for a study of the behavior of the critical frequency and the virtual height during geomagnetic storms. The disturbances have been classified for this purpose into two categories, namely: the positive and negative. The characteristics of Dst and S_D variation of f_0F2 and the S_D variation of h'F at night have been discussed. The results have been explained in terms of the quiet and disturbed day vertical drift velocities.
N

BHARGAVA, B. N., and R. V. Subrahmanyan. Geomagnetic disturbance effects in equatorial E_s. J. Atmos. Terrest. Phys. 20, 81-84 (1961).

It has been known for some time that at equatorial stations where the quiet day solar magnetic variation S_q in horizontal force is large, day time sporadic-E has some remarkable characteristics. It is very regular in its diurnal variation with the critical frequency following the cos χ law. It is also abnormally intense and often masks out the regular E-layer in routine h'-f soundings. The lunar influence on this type of E_s has been discussed by Matsushita (1957). Matsushita has shown that at Huancayo the layer often disappears suddenly for varying intervals during day-time when these intervals are between 0000 and 0300 hours or between 1200 and 1500 hours lunar time. He has also found that this disappearance was earlier than usual in the vicinity of new and full moon, particularly during winter, and that the phenomenon occurred during the first half of the periods when the lunar electric current flow in the equatorial regions was westward. Knecht

(1959) found, also at Huancayo, a lunar dependence of first appearance of E_s; during equinoxes and December solstice, E_s appeared earlier during new and full moon. Skinner and Wright (1957), from Ibadan data, observed that abnormally low values of fE_s occurred simultaneously with reduced horizontal and vertical force.

At Kodaikanal (magnetic latitude; 1.75°N; geomagnetic latitude, 0.6°N) in addition to the lunar influence, a rather remarkable association of magnetic disturbances with sporadic-E has come to our notice. We find that during the main phases of most magnetic storms, when the horizontal force was considerably subnormal, E_s disappeared suddenly. While the main features of this phenomenon were similar to those associated with lunar currents, the length of time for which E_s remained absent during storm perturbations were, on the average, considerably in excess of those associated with the lunar effect.

In order to see how the effects could be separated from those associated with the lunar current, half-hourly day time (0730-1700 hours, 75°E time) ionosonde records at Kodaikanal for a 3 year period (June 1957-May 1960) were scrutinized. To start with, all cases of E_s disappearance were grouped according to the age of the moon and the number of occurrences in each group were plotted against lunar age. It will be seen from the resulting curve (Fig. 1, lower curve) that the frequency of occurrence of the phenomenon was, in general, maximum around new and full moon with a certain amount of extraneous irregular variation. Next, when the process was repeated, with data for all disturbed days excluded, the behaviour (Fig. 1, upper curve) was more systematic with regard to the age of moon, resulting in better maxima around new and full moon and minima around first and third quarter. This is an indication that the disappearance of E_s was to a considerable extent associated with geomagnetic storm perturbations at irregular intervals, irrespective of the lunar age.

According to Matsushita (1951), the occurrence of intense E_s in equatorial regions has a connexion with the large diurnal range in H at these stations. These ranges are restricted to a narrow belt centred on "zero" dip equator and are explained by the occurrence of an intense eastward current, the so called electrojet, superposed on the normal current responsible for the daily S_q magnetic variation. The E_s disappearance at Huancayo is, according to Matsushita, caused by the westward lunar current which opposes the eastward electrojet. This is confirmed from observations of solar times of E_s disappearance at Kodaikanal where the frequency of disappearance is found to be minimum around 1100 hours which is the time at which the normal S_q and electrojet effects are maximum as seen from Kodaikanal magnetic variations.

In order to obtain preliminary results on the effects of magnetic storms on E_s, a superposed epoch analysis was carried out. From inspection of ionograms a 1/2 hr intervals the time of first disappearance of E_s was taken as zero epoch and the deviations ΔfE_s were obtained for an 8 hr period

around zero epoch. This process was carried out for twenty-seven storms recorded during the 3 year period. For the same period, departures in horizontal force and vertical force were also obtained and these together with departures in fE_s are plotted in Fig. 2. It will be seen that there is considerable correspondence between E_s disappearance and subnormal values of H and Z. The horizontal force drops by over 175γ and vertical force by about 18γ on the average, simultaneously with E_s disappearance.

It is known that the large "effective" conductivity in the dynamo region during daylight (due to inhibition of the Hall currents) associated with abnormally large solar daily magnetic variation S_q and electrojet is responsible for the formation of equatorial type E_s. While the westward current responsible for lunar daily magnetic variations the eastward currents resulting in E_s disappearance, the ring current responsible for D_{st} variation, which is also westward, appears to prevent favourable conditions for the inhibition of the Hall currents at equatorial stations. It appears that this causes a considerable drop in the "effective" conductivity in the dynamo region and results in weakening of the S_q and electrojet currents; consequently we find subnormal values of H and Z and the observed disappearance of E_s for several hours during the main phase of a magnetic storm.

A detailed study covering a period of over half a solar cycle is in progress and the results will be published in due course.
Excerpt

BHARGAVA, B. N., and R. V. Subrahmanyan. The influence of disturbed conditions and increased solar activity on geomagnetic distortion of the equatorial ionospheric F2 region. Proc. Indian Acad. Sci. 55A, 330-344 (June 1962).

The principal diurnal anomalies in the maximum electron density of ionospheric F2 layer over Kodaikanal are discussed. From an analysis of data obtained over half a solar cycle, it has been found that the phenomena of rapid increase in the electron densities following sunrise, the diurnal asymmetry and the maintenance of abnormally high ionic densities after sunset undergo systematic changes during stormy conditions. In order to examine whether these changes are accounted for by additional movements during disturbed conditions, magnitudes of movements terms of the continuity equation at three heights, for the quiet as well as the disturbed days, have been computed and discussed. The changes in the pattern of diurnal variation of N_mF2 with solar activity and the mechanism responsible for these changes are also discussed. From an analysis of published F2 layer data obtained at a number of stations with magnetic dip between ± 40°, it has been shown that the ratio of morning to afternoon peak densities yields

a fair measure of equatorial F2 layer distortion anomaly. From solar cycle variation in diurnal asymmetry, an attempt has been made to estimate the extent by which the anomalous belt widens during sunspot maximum.
PA

BHARGAVA, B. N. Lunar tidal effects in equatorial E_s. J. Atmos. Terrest. Phys. 25, 367-370 (1963).

Equatorial sporadic E-layer of the ionosphere (E_s – q), known to occur in a narrow belt in the vicinity of the magnetic equator, possesses several characteristic features. The occurrence of this layer is confined to daytime but on some days the layer disappears suddenly for varying intervals. Ionosonde records at the equatorial station of Kodaikanal (Magnetic latitude: 1°.75 N) indicate that the disappearance occurs most frequently in local summer with a minimum in equinoxes and a secondary small maximum in winter. The disappearance in E_s – q was shown by Matsushita (1957) to be of lunar tidal origin. A periodic variation in the time of first appearance of the layer at Huancayo was also shown by Knecht (1959) to be associated with lunar semi-diurnal tide. It is the purpose of this note to show that in equatorial region an additional tidal effect in E_s – q should exist and that at Kodaikanal a variability has been found not only in the time of E_s – q appearance following sunrise but also in the time of late evening final disappearance of the layer following sunset. The interval to time, during which E_s – q is present during the day, therefore, varies with the phase of the moon.

The similarity in the variability of the time of first appearance of E_s – q at Huancayo and Kodaikanal in relation to phase of the moon suggests that lunar daily variations at the two stations are practically same. The existence of strong lunar dependence in the time of first appearance as well as in the time of final late evening disappearance, reported here, lends further support to the hypothesis put forward by Matsushita (1951) regarding a close relationship between the equatorial eastward current and the origin of E_s – q.
A

BHATTACHARYA, H. Amplitude and phase spectrum of radio-atmospherics. J. Atmos. Terrest. Phys. 25, 445-450 (1963).

Derivation, by the method of Fourier-integral transformation, of the amplitude-frequency and the phase-frequency distributions for the experimentally observed waveforms of radio-atmospherics. These amplitudes

and phase distribution are also obtained by considering the return stroke current expression. A comparison of the amplitude maxima obtained from these methods suggests that discharges having sharper current pulse width are predominant.
IAA

BHATTACHARYA, H., and Manoranjan Rao. Attenuation characteristics of radio-atmospherics. J. Atmos. Terrest. Phys. 26, 263-271 (1964).

The amplitude-frequency spectra and the distances of origin of radio-atmospherics have been obtained from an analysis of the observed waveform patterns. Amplitudes, relative to the amplitude at 10 kc/s, for different frequencies over a range from 3 to 15 kc/s are then plotted against the distances of origin. For frequencies below the reference frequency of 10 kc/s it has been found that the initial decrease of the relative field intensity is followed by a gradual increase after about 12 km. On the other hand, for frequencies greater than the reference frequency, the relative field intensity has been found to increase rapidly after the initial decrease and subsequently to decrease gradually with distance. The marked difference in the nature of these curves for distances greater than 1200 km has been attributed to ionospheric reflections. It has been shown that if the received waveform pattern shows a succession of reflected impulses, then for a large distance and for large orders of reflection, higher frequencies are heavily attenuated. Due to this heavy attenuation of higher frequencies, a sinusoidal waveform of a very low frequency is expected at large distances and for large orders of reflection. The appearance of a low frequency component of 3.3 kc/s observed by Tantry and Srivastava (1958) may then be explained.
A

BHONSLE, R. V., and K. R. Ramanathan. Studies of cosmic radio noise on 25 Mc/s. at Ahmedabad. J. Sci. Indus. Res. 17A, 40- (Dec. 1958).

Attenuation of radio waves in the ionosphere is usually measured by comparing the amplitudes of repeated reflections of pulses transmitted upwards from the ground. This method is applicable only for frequencies lower than the critical frequency of the F_2 region at vertical incidence. For frequencies higher than f_0F_2, one would require a transmitter situated outside the earth's atmosphere.

Extraterrestrial radio noise sources in the galaxy provide convenient transmitters for the study of variations in the absorption and scattering of radio waves in the ionosphere.

Jansky was the first to recognize that variations in the ionosphere affect the reception of cosmic radio noise. He attributed the reduction in the intensity of cosmic noise observed during the day to the ionosphere. Systematic observations were taken by Shain using 18.3 Mc/s. in Australia. He concluded that useful information concerning the attenuation of cosmic noise passing through the whole of the ionosphere could be obtained by this means. He found that, so far as absorption was concerned, the F region was more effective than the E region. Mitra and Shain undertook an analysis of the data in greater detail and proved that the total absorption could be divided into two components, one which occurs in the D region and the other in the F_2 region. They calculated the diurnal and seasonal variations and observed that F_2 region absorption was a function of its critical frequency and not its height and suggested that increased nighttime absorption might be caused by the irregularities in the F region. Similar analysis carried out by Blum, Denisse and Steinberg revealed a partial absorption attributable at 29.5 Mc/s. to the F region or beyond. Little's work on 65 and 30 Mc/s., which is in progress at College, Alaska, is mainly concerned with high latitude effects such as sudden and intense absorptions associated with the occurrence of visible aurorae and polar blackouts. Warwick and Zirin have analysed the diurnal variation of cosmic noise at 18 Mc/s. in Colorado. Their absorption data did not allow them to separate D region absorption from the absorption produced by the other layers of the ionosphere. They consider that the absorption produced by the other layers is negligibly small.

BHONSLE, R. V., and K. R. Ramanathan. Magnetic storms and cosmic radio noise on 25 Mc/s at Ahmedabad (23°02'N, 72°38'E). Planet. Space Sci. 2, 99-103 (1960).

Studied F2 attenuation by measuring 25-Mc/s cosmic radio noise. Find disturbance diurnal variation of total attenuation depends on local time. Maximum decrease in attenuation occurs at 20 hr LT. Explain in terms of known variations of f_0F2 and F scatter on magnetically disturbed days.
M

BHONSLE, R. V. Study of solar flares using cosmic radio noise on 25 Mc/s at Ahmedabad (23°02'N, 72°38'E). Proc. Indian Acad. Sci. 51, 189-201 (1960).

Observed sudden cosmic-noise absorption on 25 Mc/s to study solar flares. Tabulates frequency distribution of flare attenuations, times of growth, direction, etc as recorded during 1956-58 at Ahmedabad. Finds absorptions stronger and more enduring than those recorded in Australia on 18.3 Mc/s in 1950-51. Classifies SCNA's as type A, B, C, or D based on form of time variation. Type A has sudden increase in absorption; type B is accompanied by sudden burst of solar noise; type C is associated with multiple or extended solar flares; and type D occurs if sun is low in sky.
M

BIBL, K., A. Paul, and K. Rawer. The frequency dependence of ionospheric absorption. J. Atmos. Terrest. Phys. 16, 324-339 (1959). (In German.)

Detailed analysis has shown that in most cases where observations did not follow the writers' old formula $L=B/(f+ L)^2 +N. \quad _3(f_0E/ \ )$, intense echos from a blanketing E_s-layer were present. The theory is generalized to the case of a thin, mirror-like E_s-layer embedded into a paraboloid E-layer (model D). This gives a new function depending on a second parameter given by the altitude of the mirror. By application of the new formula (with the actual parameters of each observation) we obtain a much better description of the observed frequency variation. Noon values of B (non-deviative D-absorption) and N (deviative E-absorption) show opposed seasonal variations, N increasing by B decreasing with the sun's height. The variation of N can be explained satisfactorily by a small decrease of the altitude of the E-layer with increasing height of the sun.
A

BIBL, K. A note regarding fluctuation of ionization in the F_2 layer. IN: Landmark, B., ed., Advances in Upper Atmosphere Research. NATO Advanced Study Institute, Corfu, July 1960, AGARD. 227 (Macmillan Co., New York, 1963).

Considerations regarding the dynamical properties of the F2 ionization are essential for the understanding of the relation between the ionospheric storms and the normal variations of the F2 ionization with time of day, season, solar cycle, geographic and geomagnetic latitude. The "traveling

disturbances" and the lunar tides are examples of the variety of phenomena occurring. It may be shown that both regarding the temporal and geographical variations of the distribution of ionization and the more rapid movements of the ionization, the F2-3000-MUF is up to now the best parameter available for a description of the phenomena. This supports the opinion of Dr. Rawer that the movements of the ionization are of great importance for the distribution of the ionization.

One mechanism that is particularly evident is the occurrence of the "F3-stratification" (which has often been referred to as "G-scatter" or "lunar-layer") which occurs in the minimum of the MUF values shortly after the minimum of f_0F2 (Bibl, 1958). In the paper referred to, the author studied the changes in the variation of the ionization of the F2 layer both in time and phase. Periods between 2 and 12 hr, and recurrence tendencies were found that indicate an "Eigenschwingung" of the ionosphere. These oscillations may be seen from ionospheric movie films and from direct recordings of ionospheric characteristics.

By comparison of MUF values from three stations, it was possible to deduce time delays of the minimum phase, corresponding to a westward drift with a velocity of about 300 km/hr. No southward drift component could be traced.

Other observations seem to have shown that the oscillations of ionization mostly occur in a direction perpendicular to the magnetic field. It has been found by phase intercomparison that the fluctuations of the minimum virtual height as observed as one European station are related to those observed at another station to the south of the first.

At the equator the amplitude of the oscillations is larger and the resonance effects are also clearer.

The correlation between stations at large distances can be very high in this region (and sometimes also negative). A comparison between the fluctuations of the F2 ionization and geomagnetic activity has been carried out.

Excerpt

BLACKBAND, W. T. The determination of ionospheric electron content by observation of Farady fading. J. Geophys. Res. 65, 1987-1992 (1960).

From a study of the Faraday fading of signals transmitted from a satellite on 20 or 40 Mc/s the total electron content between satellite and observer can be determined. In special cases a simple interpretation of the records is possible. This method can be applied to the study of the ionosphere above the F2 maximum. The results of preliminary experiments are presented. A form of satellite transmission is described which would be particularly suitable for such studies.

A

BLACKWELL, D. E., M. F. Ingham, and H. N. Rundle. Observations of twilight and night sky airglow near the equator. Ann. Geophys. 16, 152-153 (1960).

During the months of June, July and August, 1958, an expedition from the Cambridge Observatories made observations of the zodiacal light at the cosmic ray station of Chacaltaya in the Bolivian Andes. The station is situated at geographic latitude 16°4 S and geomagnetic latitude 4°9 S and being at the height of 17,100 ft, is particularly suited to optical observations of this kind. One of the purposes of the expedition was to photograph the spectrum of the zodiacal light using a spectrograph of relative aperture f/0.87 and dispersion 78 A/mm in the first order of the red region and 38 A/mm in the second order of the blue region. As the exposures were commenced soon after the end of astronomical twilight, the spectra necessarily showed twilight emission features, and this note chiefly concerns the results of measurements of the absolute intensities of these features. Some measurements of absolute intensities in spectra of the night sky are also presented.
PA

BLUMLE, L. J. Studies of the equatorial ionosphere using the Faraday effect on satellite radio transmissions. Scientific Rept. 156, Ionosphere Research Laboratory, Pennsylvania State University, University Park (March 1961).

The Faraday rotation effect on satellite signals has been used to determine the electron content of the ionosphere near the magnetic equator. The ambiguity in the total number or rotations along the ray path has been resolved by observing the satellite when the number of rotations along the ray path is essentially zero. The rotations of the plane of polarization are then counted from this point and used to determine total electron content. Observations of the total electron content of the ionosphere made over a four-month period are presented and compared with values obtained from the dispersive Doppler method. The total electron content results are compared with those obtained using a Chapman extrapolation for the electron density profile above the electron density peak.
STAR

BLUMLE, L. J., and W. J. Ross. Satellite observations of electron content at the magnetic equator. J. Geophys. Res. 67, 896-897 (1962).

The rotation of the plane of polarization of a radio wave propagating through the ionosphere has been used by several workers to determine the total electron content of the ionosphere, using lunar reflections [Browne, Evans, Hargreaves, and Murray, 1956; Evans and Taylor, 1961] and satellite beacons [Garriott, 1960].

$$\Omega = \frac{2.36 \times 10^4}{f^2} \overline{B_L \sec \chi} \int N \, dh \qquad (1)$$

where

Ω = rotation angle in radians.
N = electron density.
B_L = component of magnetic field along ray path.
f = wave frequency.
χ = zenith angle of ray path.
dh = a height element

$\overline{B_L \sec \chi}$ = a weighted mean for the range of integration.

All quantities are in rationalized mks units.

The value of $\overline{B_L \sec \chi}$ at 400 km was chosen for the observations discussed in this paper, where the height range is to 1000 km.

If Ω can be measured without ambiguity, equation 1 may be used to determine total content. In most cases Ω cannot be measured unambiguously. However, by using closely spaced frequencies [Evans and Taylor, 1961] or by estimating the relatively small number of rotations in a direction that approaches the transvers condition [Garriott, 1960], it is possible to determine Ω to a fair degree of accuracy. Alternatively, if horizontal stratification is assumed, changes in Ω between two directions may be used to estimate the value of Ω.

For a station on the magnetic equator, there is a time during each satellite pass where $B_L = 0$ along the entire ray path. The quasi-longitudinal (QL) approximation of the Appleton-Hartree index [Ratcliffe, 1959] is not valid, and equation 1 does not apply. The quasi-longitudinal approximation is valid at 54 Mc/s when the sine of the angle θ between the field and the ray is less than 0.9974. The maximum time taken for a satellite at 1000 km radiating 54-Mc/s signals to travel through the quasi-transverse condition ($\sin \theta > 0.9974$) is about 3 seconds, and in general this is only a small part of an observed satellite pass.

Observations of the 54-Mc/s signals from 1961 o_1 (Transit 4A) have been made at a station on the magnetic equator near Huancayo, Peru, since September 1961. The signals are received on a fixed dipole antenna connected to a fixed gain crystal-controlled receiver. A magnetic tape recorder is used to record the signal amplitude and timing marks from a clock. A record is then produced from the magnetic tape on a pen recorder, a typical record of which appears in Figure 1. The time of the transverse condition is obtained from the orbital ephemeris. The rotations are then counted (see Fig. 2) from the transverse condition and used in equation 1 to determine total content.

The average results of two quiet-day ($\Sigma K_p < 20$) observations are shown in Table 1. They may be compared to mid-latitudes values for the same time, which are about $1.5 \times 10^{17}/m^2$ (to be published). The errors in the

TABLE 1

Date, 1961	Time	$N\,dh/m^2$	$N\,dh/N_{h_{max}}$, km
Sept. 18	1553	4.39×10^{17}	370
Sept. 20	1711	3.64×10^{17}	353

values tabulated are principally scaling errors and in the height chosen for B_L sec X, but it is estimated that these do not introduce more than a 5 percent error in $\int N\,dh$.
Excerpt

BLUMLE, L. J. Satellite observations of the equatorial ionosphere. J. Geophys. Res. 67, 4601-4605 (1962).

A method of measuring total electron content by observing the Faraday effect on satellite beacon transmitters at a station located on the magnetic equator is presented. The method is applied to data observed at Huancayo, Peru, between September 1961 and January 1962. The total electron content at the magnetic equator has been found to have nearly a ten to one diurnal variation with a maximum of $4 \times 10^{17}\ m^{-2}$ near 1500 hours. Values of the thickness parameter $\int N dh/N_{max}$ for the observational period show an anomalous increase around layer sunrise which is attributed to a departure from thermal equilibrium.
A

BONNET, G. Peculiarity of the F2 layer at Lwiro. Ann. Geophys. 10, 348-350 (1954).

An analysis of very rapid variations of heights of the F2 nighttime peak during equinoctial periods is given. An increase of the peak altitudes is very often related to the presence of a layer corresponding to a nighttime E layer.
MGA

BOOKER, H. G., and H. W. Wells. Scattering of radio waves by the F region of the ionosphere. Terrest. Mag. 43, 249-256 (1938).

Records are reproduced showing diffuse echoes from the F-region of the ionosphere received continuously at night in equatorial regions over a wide range of wave-frequency. They are interpreted as due to Rayleigh

scattering by spatial irregularities in the distribution of electron-density at or above a definite level in the F-region. Because of the highly dispersive nature of the ionosphere, there is no marked dependence of Rayleigh scattering upon wave-frequency such as there is for a non-despersive medium. According to this interpretation, variation of the maximum wave-frequency to which diffuse echoes can be followed has nothing to do with variation of the maximum electron-density of an ionospheric region, but merely indicates variation in the size of irregularities in electron-density. Scattering of this type may have some bearing upon the phenomenon of presistence of E-region echoes to wave-frequencies greater than the critical penetration-frequency of the E-region.
A

BOSE, S. N. The total reflection of electromagnetic waves in the ionosphere. Indian J. Phys. 12, 121-144 (1938).

A mathematical discussion of the propagation and reflection of waves in which the method of characteristics is applied to the microscopic equations of Lorentz.
M

BOSSOLASCO, M., and A. Elena. On some characteristics of the Es-layer. Planet. Space Sci. 1, 205-212 (1959).

Study dependence of Es ionization on geomagnetic field. State that solar radiation is chief factor controlling magnitude of foEs everywhere. Plot absolute maximum values of hourly median values of foEs vs latitude. Find minimum near equator, two maxima near equator, two maxima near 15° or 20° latitude, and a sharp minimum at about 35° latitude in southern hemisphere. Conclude that mean characteristics of Es layer are controlled by normal current distribution responsible for Sq. Investigate drift of Es regions making use of time displacement presented by diurnal maximum of foEs medians as revealed by isopleth representation. Say method appropriate only for deducing prevailing zonal winds in season where maxima of foEs medians occur very clearly. Deduce that in summer zonal westward drift of Es in forenoon reaches mean values of order of 1,100 km/hr. Find that in northern hemisphere westward drift generally prevails during summer and in forenoon.
M

BOSSOLASCO, M., and A. Elena. On the lunar semidiurnal variation of the D and F2 layers. Geofis. Pura Appl. 46, 167-172 (1960).

Deduce linar semi-dirunal variation of absorption at Freiburg and of foF2 at Genova, Freiburg, and Leopoldville. Find morphology of lunar semi-diurnal variation controlled by magnetic dip rather than geomagnetic latitude.
M

BOWLES, K. L., and R. Cohen. NBS equatorial region VHF scatter research program for the IGY. QST 41, 11-15 (1957).

A cooperative program of research on ionospheric scattering will be conducted by scientists and radio amateurs in the United States and the other Americas during the International Geophysical Year. Transmitting and receiving stations are soon to be installed in South America by the National Bureau of Standards. The transmissions will be beamed northward toward Central and North America and eastward across South America. Radio amateurs are asked to provide reports of their reception of signals from these stations. This article traces the background leading to the design of this project and outlines the experimental arrangement.
A

BOWLES, K. L., and R. S. Cohen. Observations of F-layer scatter near the magnetic equator. Paper presented to URSI Spring Meeting, Washington, D. C., May 1959.

No abstract available.

BOWLES, K. L., and R. Cohen. Studies of scattering phenomena in the equatorial ionosphere based upon V.H.F. transmissions across the magnetic equator. IN: Beynon, W. J. G., ed. Some Ionospheric Results Obtained During the IGY, Proc. Symposium URSI/AGI Committee, Brussels, Sept. 1959, 192-194 (Elsevier Publishing Co., New York, 1960).

Results have been attained pertaining to the phenomena of equatorial sporadic E, equatorial spread F, and propagation by means of ionospheric radio wave scattering at v.h.f. near the magnetic equator. These studies are the results of I.G.Y. experimentation in South America utilizing 50 Mc/s transmission crossing the magnetic equator at Huancayo, Peru, and over

other oblique paths. Additional ionospheric experiments were also conducted in Huancayo at vertical incidence.

It has been established that a close relationship exists between the magnetic manifestations of the equatorial electrojet current above Huancayo, the occurrence on Huancayo ionograms of equatorial sporadic E, and the intensity and fading rate of v.h.f. signals propagated by the ionosphere over Huancayo. The zone in which E region effects of the equatorial current-stream are apparent extends over some 10° of latitude. Also the scatter propagation in the equatorial ionosphere is characterized by higher signal-levels and by more rapid fading-rates than are observed in the ionosphere at temperate latitudes, and signal-strengths remain high throughout the night. The feasibility of utilizing ionospheric scattering for communications in equatorial regions seems quite promising. Curiously, ionospheric scatter propagation at v.h.f. similar to that associated with sporadic E formations in temperate latitudes is observed from time to time just to the North and South of the magnetic equator, but its occurrence appears to be excluded in the immediate vicinity of that equator. Further a remarkable sensitivity to polarization was established in h.f. radar echoes obtained at vertical incidence from the diffuse region (bounded by the slant sporadic E and extending to the q-type sporadic E), comprising the typical magnetic-equatorial sporadic E configuration appearing on Huancayo ionograms. These diffuse echoes were obtained with an antenna-array polarized magnetic North-South, but were virtually eliminated upon using an East-West polarized antenna-array for transmitting and/or receiving.
A

BOWLES, K. L., R. Cohen, G. R. Ochs, and B. B. Balsley. Radio echoes from field-aligned ionization above the magnetic equator and their resemblance to auroral echoes. J. Geophys. Res. 65, 1853-1855 (1960).

During the International Geophysical Year, under the joint auspices of the United States National Committee for the IGY, the Voice of America, and the National Bureau of Standards, we operated a chain of 50 Mc/s VHF forward scatter circuits near the magnetic equator in South America [Bowles and Cohen, 1957]. An intense mode of VHF propagation associated with equatorial sporadic E was found to occur and was demonstrated to be closely identifiable in time-variation and height with the equatorial electrojet. (A brief account of these findings was published by Gates (1959) and a more comprehensive report will be submitted shortly for publication.) As a result of Stanford University IGY backscatter studies at Huancayo, Egan (Stanford University Radio Propagation Laboratory Tech. Rept. 1, December 30, 1959, unpublished) confirmed our expectation [Bowles and Cohen, 1957] that the radio echoes from irregularities in the vicinity of the equatorial E region exhibit a magnetic-field related aspect sensitivity

similar to that of radio echoes from auroral ionization. To better understand the irregularities in the equatorial electrojet region where these unusually strong forward scatter signals are propagated, we have mounted various VHF and HF radar and CW experiments of short duration. It is the purpose of this communication to relate the essential first results of this research before the submission of a more detailed report.

At Huancayo, strong daytime echoes from equatorial sporadic E can be observed at 50 Mc/s throughout the plane normal to the lines of force of the earth's magnetic field. This plane is nearly veritical and oriented in the magnetic east-west direction. Typically, signal-noise ratios as high as 20 decibels can be obtained using simple Yagi antennas, 10 kc/s receiver bandwidth, and 5 kw of peak power. At vertical incidence the polarization of the echoes is parallel to that of the transmitting antenna, independent of the orientation of the latter. No significant cross-polarized component can be observed. The echoes arise within a zone approximately 7 km thick, the center of which is between 100 and 105 km above sea level. The layer is present in varying strength daily during the daylight hours. During most of this time its characteristics are nearly uniform in the east-west zone within line of sight from the station.

The echoes fade rapidly in a manner reminiscent of auroral echoes obtained at roughly the same frequency Bowles, 1954; Nichols, 1959 . We have measured their frequency spectra with a panoramic spectrum analyzer, not only at vertical incidence, but at various oblique angles toward the east and west. At vertical incidence the spectrum of the echoes is symmetric about the transmitted frequency and usually from 100 to 200 c/s wide. Looking toward the east the spectrum is ordinarily shifted upward in frequency by about 125 c/s; looking toward the west it is ordinarily shifted downward by an equal amount. This observation would normally be interpreted as evidence of a horizontal drift of irregularities from east to west at velocities of the order of 750 meters/sec. However, it is noted that an identical shift in the maximum of the spectrum is obtained looking at both 30 and 60 degrees from the vertical, while geometrical considerations related to the line-of-sight component of a horizontal drift would suggest that these shifts should be related in the ratio 0.5/0.86.

Using two antenna spaced along an east-west baseline, we also searched for evidence of this drift by correlating the fading patterns at various time separations. At vertical incidence we were unable to find any evidence of a drift. At oblique incidence, however, there was clear evidence of a drift having approximately the horizontal velocity inferred from the Doppler-shift measurement at the same angle of incidence.

We regard the results of these two experiments as evidence that the irregularities viewed by the radar at one angle of incidence differ in some manner from those viewed at other angles of incidence, even when both angles lie within the plane normal to the lines of force of the earth's magnetic field. Because of the uniformity of the equatorial scattering zone

in which the irregularities are observed, we infer that the same result would have been obtained had the irregularities within a given region been observed from various angles. We therefore suggest that the presently accepted model of thin ellipsoidal field-aligned irregularities [Booker, 1956] does not explain the echoes we have observed. A model consistent with our results is one in which the irregularities are plane wavefronts, the wave normals of which are distributed in a plane normal to the magnetic field lines. These wavefronts are perhaps longitudinal hydromagnetic waves of electron-density. The transverse dimensions, i.e., correlation distances, of these wavefronts would have to be several hundred meters or more. This is also evident from the results of a second series of experiments along a north-south baseline.

The separation between antennas along a north-south baseline required for a 1/e correlation at 50 Mc/s was of the order of 35 wavelengths. For a fixed separation of about 15 wavelengths, the correlation varied with time between the limits of about 40 per cent and 80 per cent. Comparison of nearly simultaneous spaced-receiver experiments at 50 and 21.8 Mc/s indicated that the correlation was identical at the two frequencies for the same antenna separation measured in wavelengths. This indicated that the north-south angular width of the sector defining the scattered echoes was the same at both frequencies. We then performed a test with a wide-spaced north-south interferometer (35 wavelengths) using 10 microsecond pulses (1.5-km radar-range) and a receiver bandwidth of 100 kc/s. The lobe orientation was adjustable within the ambiguity of the lobe spacing of about 1.6 degrees. A-scope photographs were taken at successive steps of 0.4 degrees of the interferometer lobe orientation. These demonstrate that it was possible for us to discriminate against the lower part of the echo (at about 100-km range) while simultaneously favoring the upper part of the echo (at about 105-km range), or vice versa. This result suggests that the signal energy from the upper part of the equatorial sporadic E layer may arrive from a slightly different direction than that from the lower part. For an echo angular spectrum distributed over about 0.6 degree, the observed north-south correlation of about 35 wavelengths would be obtained.

These interferometer results could arise if the magnetic inclinations at the top and bottom of the equatorial sporadic E layer differed by about 0.6 degree, and if the irregularities themselves were characterized by a correlation distance much greater than 35 wavelengths. It is reasonable to suppose that the inclination of the magnetic lines of force may vary with height in this manner, as a consequence of the strong currents flowing in the electrojet. To test this hypothesis further we made a series of observations of the correlation coefficient for a north-south baseline of 15 wavelengths. We found that the correlation coefficient was lowest, and hence the angular spectrum of the echoes widest at times when the H trace of the Huancayo magnetogram indicated the electrojet current to be strongest. This is consistent with the picture that the electrojet current slightly distorts

the magnetic lines of force. Huancayo is situated where the magnetic inclination is about 2 degrees, and hence is about 1 degree of latitude from the midpoint of the electrojet region. On the other hand, from symmetry considerations it is to be expected that the inclination would be horizontal at the midpoint of the electrojet, both at the top and bottom of the current sheet.

The VHF echoes described in the foregoing paragraphs bear a striking resemblance to VHF echoes from E-region auroral ionization. Both classes of echoes occur in about the same height range of the ionosphere. Both have about the same bandwidth of fading and similar Doppler-shift characteristics. Both kinds of echo exhibit an aspect sensitivity corresponding to the influence of the earth's magnetic field, although in both instances strong echoes can be observed along propagation paths which are not precisely orthogonal to the lines of force of the static magnetic field of the earth. Strong currents are observed to flow horizontally normal to the lines of force of the earth's magnetic field both at the magnetic equator and in auroral forms such as the homogeneous-arc or the rayed-band. Because of these similarities, it is tempting to infer that the conditions creating the irregularities responsible for radio wave scattering might be identical in both cases. We therefore suggest that in both the auroral and equatorial phenomena the irregularities could reasonably consist of a family of plane-wave disturbances constrained to lie parallel to the local lines of force of the earth's magnetic field. The velocities of these plane waves might be a function of their angle relative to the direction of the current, as indicated in both cases by the fact that the Doppler-shift data are inconsistent with simple drift motions [Leadabrand, Presnell, Berg, and Dyce, 1959]. We further propose that the apparent weakness of the aspect sensitivity in both cases could be produced by local distortion of the earth's magnetic field due to the flow of strong localized ionospheric currents.
Excerpt

BOWLES, K. L. Equatorial electron density profiles to 5000 kms, using the incoherent scatter technique. Committee on Space Research, The Hague, Netherlands (May 1962).

Profiles of electron density over the height range 100 to 5000 Kms are being measured using an incoherent scatter radar near the magnetic equator at Lima, Peru. The method produces a profile continuous through this height range. New observations are made at intervals of less than one hour permitting study of dynamic changes in the profile. Measured profiles are given as typical examples for daytime and nighttime. The electron density approximate 10^5 per cubic centimeter at 600 Kms, 10^4 at 1100 Kms and 10^3 at 4000 Kms. An intermediate region appears between 700 and about

2000 Kms. A distinct widening of the scatter spectrum at about 2000 Kms suggests the beginning of the protonosphere. Prospects are good for increasing the maximum height to 30,000 Kms within the next several months.
STAR

BOWLES, K. L., et al. Profiles of electron density over the magnetic equator obtained using the incoherent scatter technique. NBS Tech. Note 169, National Bureau of Standards, Boulder, Colo. (Dec. 18, 1962).

Electron density profiles (obtained near Lima, Peru), using the incoherent scatter measurement technique of Bowles et al. (1962), are presented. Profiles reported were obtained with the radar antenna directed three degrees away from the perpendicular. Under this arrangement, the coherent echo power should be reduced perhaps three to four orders of magnitude relative to the perpendicular. Coherent irregularities are, therefore, ignored for analysis of most of the profiles. Transmitter peak power and antenna cross-section values are given for the months January, February, and April of 1962. The profiles obtained are reliable up to 200 km, but the electron densities indicated below that height are overestimated.
STAR

BOWLES, K. L. Recent radar observations of new forms of ionospheric scatter. IN: Beynon, W. J. G., ed. Neonograph on Ionospheric Radio, XIIIth General Assembly of URSI, 200-209 (Elsevier Publishing Co., New York, 1962).

Discussion of some recent developments which show promise of providing information on the kinetic and dynamic nature of the ionosphere. It is noted that new propagation phenomena, particularly within the realm of scattering processes, have usually been discovered each time significant improvements in radar sensitivity have become possible. Further discoveries have frequently followed when these higher sensitivities have been employed in untried geographical regions. The results discussed stem from the application of one or both of these approaches by U.S. groups since 1957. Specifically covered are VHF echoes from the D region, and field-aligned echoes observed at low frequencies including observations from the Caribbean, from Stanford University, and both IGY and National Bureau of Standards measurements at the magnetic equator.
IAA

BOWLES, K. L. and R. Cohen. A study of radio wave scattering from sporadic E near the magnetic equator. IN: Smith, E. K., and S. Matshushita, ed. Ionospheric Sporadic E. 51-77 (Pergamon Press, Inc., New York, N.Y. 1962).

Sporadic-E irregularities in the equatorial ionosphere have been simultaneously studied with an ionosonde located at Huancayo, Peru, and by means of radio-wave scattering at 50 Mc/s. The latitude dependence of oblique scattering has been observed over paths in the vicinity of the magnetic equator. A close relationship has been established between the strength of the scattering irregularities associated with equatorial sporadic E and the intensity of the equatorial electrojet current. Radar studies at Huancayo suggest that the equatorial sporadic E irregularities in the electroject are plane wave fronts parallel to the earth's magnetic lines of force. On this model, the wave normals to these planar irregularities are distributed at various angles in a surface normal to the magnetic field lines, and the planes move westward at velocities which are a function of these inclination angles. The slanted trace heretofore described as "equatorial slant sporadic E" is demonstrated to be a configuration arising from echoes in the east-west plane from the equatorial sporadic E-layer.
J. Res. NBS

BOWLES, K. L., B. B. Balsley, and R. Cohen. Field-aligned E-region irregularities identified with acoustic plasma waves. J. Geophys. Res. 68, 2485-2501 (1963).

This paper describes some measurements related to the nature of field-aligned irregularities in the E region. The measurements were performed near the magnetic equator, and the irregularities are attributed to the equatorial electrojet. It is shown that the irregularities are most likely to consist of plane acoustic waves generated by an instability resulting from the flow of current in the electrojet. Reference is made to a recent theory of Farley in which the existence of such waves is predicted. The characteristics of auroral radar echoes are shown to be similar to those of the equatorial echoes. It is inferred that the auroral field-aligned irregularities are also caused by the flow of electrojets.
A

BOWMAN, G. G. A relationship between spread-F and the height of the F2 ionospheric layer. Austral. J. Phys. 13, 69-73 (1960).

The variation, throughout the night, of range-spreading spread-F widths, at Brisbane, is investigated. Evidence is presented to support

the hypothesis that the ripple amplitude of the spread-F ionospheric irregularities varies directly with the layer height. This leads to an association between the range-spreading width and the height of the layer.

Certain aspects of frequency-spreading are also discussed.

A

BOWMAN, G. G. Further studies of "spread-F" at Brisbane - I Experimental. Planet. Space Sci. 2, 133-149 (1960).

Rotating-spaced loops at Brisbane recorded the azimuths-of-arrival of pulsed signals at the same frequency, from a transmitter on the site of the loops.

These and other normal-incidence records indicate that the irregularities of the F2-layer responsible for "Spread-F" records at Brisbane, are ripples of considerable lateral extent with a "wavelength" varying from 20 km to over 100 km. The position of the ripple in each ionization contour changes with height in such a manner as to suggest a simple relationship with the geomagnetic field orientation.

Seasonal variations of the phenomenon show a winter maximum and a summer sub-maximum, and there is a distinct inverse sunspot-cycle relationship. The type of spreading defined as range-spreading generally has a peak of occurence around midnight, and that defined as frequency-spreading peaks during the sunset and sunrise periods, after an allowance is made for a diurnal variation associated with the changing f_0F2 value.

A

BRAMLEY, E. N. Some comparative directional measurements on short radio waves over different transmission paths. Proc Inst. Elec. Engrs. 102B, 544-549 (1955).

From observations of transmissions on 5-8 Mc/s from Aberdeen to Winkfield, entirely over land, and Hemsby, mainly over sea, it is concluded that correlation of closely corresponding components of F layer tilt is generally negligible. A daily variation of tilt approximately E-W occurs at about 0.2 /h. On second order F layer transmissions over 700 km, the land acts as a rougher reflector increasing the rapid directional fluctuations of the echo but not the total bearing variance, mainly caused by the ionospheric tilts.

N

BREMMER, H. Terrestrial radio waves. (Elsevier Publishing Co., New York, 1949).

As radio technique developed the question arose of what range may theoretically be expected for waves sent out by a transmitter of a given strength and in a given position. Speaking mathematically-physically, this means that the electromagnetic field, and, more especially, the magnitude of the electric field, should be determined when the transmitter is a given source of electromagnetic waves. Whereas this problem is comparatively simple for a transmitter in empty space, it becomes very difficult when we take into account the disturbance caused by the spherical earth. As a result of this influence we are faced with a problem of diffraction, which may be compared with that of the exact determination of the distribution of light in a space where the light coming from a given source is intercepted by screens or similar obstacles. Whereas this particular kind of problems may be solved in certain cases – as that of a screen formed by a half plane – with the aid of integrals, the same does not apply to our diffraction problem.

As in many other practical problems, the matter under consideration has to be greatly idealized. This is necessary in order not to make the calculations too involved; of course, any simplifications introduced should not exercise too great an influence quantitatively. In our case these simplifications comprise the following points:

(1) The transmitter (that is, the transmitting antenna) is imagined to be of infinitely small dimensions. In practice, this means that the length of the aerial should be small in comparison to the wavelength. It should be borne in mind, however, that the field of a transmitter of finite length (in which the current is not necessarily the same at all points) may be obtained by integration from a superposition of infinitely small transmitters.

(2) The earth is imagined to be spherical and homogeneous. With respect to its electrical properties the earth is then completely characterized by the dielectric constant, ϵ, and the conductivity, σ: the earth, therefore, is at the same time a dielectric and a conductor.

(3) Suppositions regarding the constitution of the atmosphere. The simplest way is to assume the atmosphere to consist of empty space, i.e., non-conductive and with a dielectric constant equal to 1. This amounts in the first place to neglecting the influence of the ionosphere (the conductive layers in the upper atmosphere), and also that of the refraction in the lower atmosphere, which is chiefly caused by the differences in the vapour content at different heights above the ground. It is especially the ionosphere which renders possible the propagation of the waves over long distances; this is, however, of less importance for shorter distances, especially during the day-time, because then the lower layers of the ionosphere (the so-called D- and E-layers) are strongly developed and absorb the radio waves instead of acting favourably for their propagation.

In the present work we shall discuss, in Chapters VII – XI, inclusive, the influences of the ionosphere and the refraction in the lower part of the atmosphere. In Chapters II – VI, inclusive, these influences will be entirely ignored, so that the atmosphere is there imagined to consist of empty space. The results obtained in this way apply, in accordance with what we said above, especially to day-time; they equally apply to night-time for those distances at which the field caused by the ionosphere (the so-called sky-wave) is small as compared to the direct field (the 'ground-wave').

The mathematical formulation of our problem will then be as follows. Of Maxwell's equations a solution is required satisfying the following conditions:

(1) Outside the earth the equations for free space are valid; inside the earth the equations corresponding to the values of ϵ and σ assumed to exist there.

(2) The field is singular at the transmitter (point source) which prescribes the character of this singularity.

(3) On the earth's surface the field satisfies the usual conditions at an interface of two media, i.e., the tangential components of the electric and magnetic fields are continuous there.

Excerpt

BRIGGS, B. H., G. J. Phillips and D. H. Shinn. The analysis of observations on spaced receivers of the fading radio signals. Proc. Phys. Soc. B 63, 106-121 (1950).

The fading of a radio wave once reflected from an irregular ionosphere is discussed in terms of the variable diffraction pattern produced at the ground. It is pointed out that fading may arise either by a drift of the diffraction pattern past a receiver, or by irregular variations in the pattern, or by both mechanisms together. It is shown how, from observations at three receiving points, it is possible to deduce the rate at which the pattern is changing and the velocity with which it drifts over the ground. This velocity is of interest as it may be related to the wind velocity at ionospheric heights in the atmosphere, but the relation of the diffraction pattern to the irregular ionosphere which produces it is not discussed in detail.

A

BRIGGS, B. H., and G. J. Phillips. A study of the horizontal irregularities of the ionosphere. Proc. Phys. Soc. B 63, 907-923 (1950).

The theory of diffraction by a random screen developed by Booker, Ratcliffe and Shinn is presented in a convenient form for practical application in ionospheric experiments. It is shown that measurements of the correlation of the fading of the reflected wave observed at spaced receiving points can be used to find the extent of the angular spreading of the down-coming wave.

Histograms are given to show the frequency of occurrence of different degrees of angular spreading observed during a series of experiments using pulse transmissions at vertical incidence.

For a frequency of 2.4 Mc/s. it is most common to find that the downcoming wave has an angular spread such that the amplitude falls to half value at an angle of 5° for regions E and F. For region F observed on 4.8 Mc/s., the corresponding value is 2.5°. There is no evidence for any pronounced seasonal or diurnal variations.
A

BRIGGS, B. H. An investigation of certain properties of the ionosphere by means of a rapid frequency-change experiment. Proc. Phys. Soc. B 64, 255-274 (1951).

The paper is concerned with the recording of various characteristics of a radio wave reflected from the ionosphere as the frequency is altered rapidly.

An apparatus is described in which a receiver is kept in tune with a sender by means of automatic frequency control circuits operated by the direct pulse from the sender. The tuning is corrected by each pulse and remains fixed for the time between pulses. A frequency range of 1 Mc/s. can be covered in 1 sec. and may be selected anywhere in the range 2-20 Mc/s.

A number of applications of the apparatus are described and typical records are reproduced. The irregularities of ionization present in the normal regions are investigated by the observation of the irregular variations of the amplitude of the reflected wave which are produced when the frequency is altered. Irregularities of ionization are sometimes found to be localized in height. Observations of the reflection coefficient of the abnormal region E suggest that there are two distinct types of region, one an irregular region consisting of scattering clouds, the other a coherent layer with a thickness of the order of 5 km. The apparatus is also used to study the behaviour of the subsidiary critical frequencies often present below the main critical frequency of region E. It is found that these are always decreasing in critical frequency whenever they are observed. Records of amplitude and group path near the critical frequency of a region can be used to determine the collision frequencies of electrons. The treatment is mainly descriptive, and a full discussion of those records which require a detailed quantitative analysis is reserved for a later paper.
A

BRIGGS, B. H., and M. Spencer. Horizontal movemonts in the ionosphere. Rept. Progr. Phys. 17, 245-280 (1954).

The object of the paper is to survey the existing knowledge of horizontal movements in the ionosphere as obtained by radio methods. After a brief introduction the vaious methods and associated results are described under

the following main headings: Relected radio waves observed at closely spaced points; observations of movements of large scale irregularities in the F region; observations of waves from radio stars; observations of waves reflected from meteor trails; observations of waves reflected from the sporadic-E layer. The most detailed discussion is accorded to the first of these methods, with which the authors have been personally associated. The results obtained at Cambridge, England, by this method are compared with the results obtained by other workers using this and the other methods in different parts of the world. The following conclusions are reached: At all levels in the ionosphere systematic as well as irregular horizontal movements are present. Typical velocities are of the order of 80 m/sec; there is a tendency for the velocity to increase with height. The systematic movements have the form of regular diurnal and seasonal variations and show considerable consistency between observations made in the Northern and Southern hemispheres. At heights around 100 km the semi-diurnal components of the velocity, as determined by Fourier analysis are found to represent a uniformly rotating velocity vector; the direction of the rotation is clockwise in the Northern hemisphere and anti-clockwise in the Southern hemisphere. This is the type of movement predicted by the theory of atmospheric oscillations, though the phase of the rotation is not that expected theoretically. At times of magnetic disturbance the velocities of the horizontal movements are increased, and this phenomenon becomes more marked with increasing height in the atmosphere. At 300 km velocities as high as 1000 m/sec have been recorded during magnetic storms. The report ends with a brief summary of observations by non-radio methods.
A

BRIGGS, B. H. A study of the ionospheric irregularities which cause spread-F echoes and scintillations of radio stars. J. Atmos. Terrest. Phys. 12, 34-45 (1958).

A study is made of the correlation between the occurrence of spread-F echoes at Slough, Inverness and Oslo. It is concluded that the ionospheric irregularities which cause the spreading occur in patches which have dimensions of the order of 500 km in a NS direction, and considerably greater in the EW direction. There is an indication that these "bands" of irregularities may lie along lines of magnetic latitude, and they tend to occur in the same geographical position of successive nights. The correlation of the scintillations of the radio star in Cassiopeia with the occurrence of spread-F echoes at two places is investigated. The results are found to be consistent with the same picture of the spatial distribution of the irregularities. Some indirect arguments suggest that the irregularities causing the scintillations are at heights near 300 km.
A

BRIGGS, B. H. Survey of ionospheric drifts. IN: Beynon, W. J. G. ed., Ionospheric Radio, 219-239 (Elsevier Publishing Co., New York, 1962).

This survey is intended to summarize the present knowledge concerning horizontal drifts and tidal oscillations in the upper atmosphere. An attempt will be made to present a world-wide picture, and for this reason emphasis will be placed on methods of observation which have been used at several places, and which have contributed most to the general picture. Some form of selection is in any case necessary in order to keep the survey within the permitted length. Topics which will not be discussed include movements of Es patches, auroral and airglow movements, drifts of noctilucent clouds and acoustical methods of drift measurement. Papers giving results of observations by these methods are, however, included in the bibliography, which has been made as complete as possible. Vertical tides are not discussed. The omission of these topics, is not, of course, meant to imply that they are of small importance, and it is hoped that they will be covered in the later detailed discussions, and, if possible, brought into relation to the general picture presented in this survey.

It will not be possible in the space available to describe experimental techniques, and for such descriptions reference must be made to the original papers or to earlier reviews. For the same reason, methods of analysis of records will not be treated; again it is hoped that this topic can be adequately covered in the later discussions. Theories of movements and irregularities in the upper atmosphere will be discussed in the paper by C. O. Hines (p. 238).

A

BRIGGS, B. H. Observations of radio star scintillations and spread-F echoes over a solar cycle. J. Atmos. Terrest. Phys. 26, 1-23 (1964).

Observations of the scintillations of the radio source Cassiopeia A were made at Cambridge on a frequency of 38 Mc/s over the period 1949 - 1961. The results are presented in the form of curves showing the mean diurnal variation of the scintillation index for each month. The variations of scintillation index with solar time, sidereal time and zenith angle are derived and discussed. Seasonal and solar cycle variations are also considered. Ionograms from Slough were analysed to study the occurrence of spread-F echoes for the period 1949-1960, and the results are compared with the observations of scintillations. Special consideration is given to the variations with the solar cycle, which are opposite for the two phenomena; the scintillation effect is greatest at sunspot maximum, but spread-F echoes occur more frequently at sunspot minimum. It is concluded that at sunspot maximum the ionospheric irregularities which cause radio star scintillations must be mainly above the level of maximum ionization of the F-region, and are therefore unobservable by ground-based sounders. For the years

near sunspot maximum, scintillations occur frequently by day as well as by night. Possible explanations of these daytime scintillations are considered.
A

BROWN, R. A. Lunar variations of the F2 layer at Ibadan. J. Atmos. Terrest. Phys. 9, 144-154 (1956).

Regular readings of F2-layer parameters taken at Ibadan from December 1951 to April 1954 have been analysed for lunar and luni-solar variations. Harmonic analysis shows that the lunar variations of h_mF2, y_mF2, f_0F2, and h'F2 are semidiurnal and of considerable amplitude. These variations are presented as harmonic dials. They show marked seasonal variation of amplitude and phase. The luni-solar effects are also large; the phase of the lunar oscillations changing by particularly large amounts during the course of a solar day. Values of the recombination coefficient at various heights in the F2 region are deduced from the luni-solar variations, and shown to be consistent with an exponential decrease with height.
A

BUKIN, G. V. Ionospheric observations over the Atlantic Ocean. Geomag. Aereon. 1, 728-731 (1961). (Original in Russian.)

A thorough analysis of ionospheric observations over the Atlantic in 1958-1959, by means of vertical soundings showed that the equatorial ionosphere substantially differs from the ionosphere in the middle latitudes. The results of the analysis are represented in graphs.
MGA

BURKARD, O. Studies of the height oscillations of the F2-layer. II. Geofis. Pura Appl. 16, 117-122 (April-June 1960). (In German.)

The records of 8 stations show that the minimum height of the layer shows a variation with a period of half the sunspot cycle. A Peruvian

station, Huancayo, shows a large variation with the same period as the sunspot cycle superimposed on this double peaked variation.
PA

BURKARD, O., and R. Eyfrig. Studies of the height oscillations of the F_2-layer. III. Geofis. Pura. Appl. 16, 123-127 (April-June 1950). (In German.)

It is necessary to distinguish between the minimum height and the height of maximum electron concentration in the F2-layer. Near the equator there is a considerable difference between these heights, and the height of maximum electron concentration increases with the number of sunspots while the minimum height decreases.
PA

BURKARD, O. Electron annihilation in the F2-layer. Int. Ass. Terrest. Mag. Elec. Bull., 13, 381-385 (1950).

If the influence of variable activity of the sun is eliminated from the nightly diminution of the F2-ionization, there results a linear law in the form of $dn/dt = \beta n$. The value of β is found to be about $1 \cdot 10^{-4}$ sec^{-1}. The seasonal variation of β is investigated for the stations Huancayo, Kochel (near Munich), and Watheroo. If this variation is due to a temperature-effect, the summer temperature must be about three times larger than the winter temperature at middle latitudes.
PA

BURKARD, O. Studies on the ionospheric tidal effect. J. Atmos. Terrest. Phys. 1, 349-352 (1951). (In German.)

The F_2-layer critical frequencies at Huancayo show a luni-solar daily variation of the same kind as that found in the components of the earth's magnetic field: the simidiurnal lunar variation is pronounced during the day-time only, and is practically absent during the night. Because of the great variability of the individual night-values of fF_2, the phases of the M_2-tide computed for night-hours must be regarded as accidental.
PA

BURKARD, O. Some comments on the geomagnetic effect in the F2-layer. Proc. Mixed Commission on the Ionosphere, Brussels, 16-18 Aug. 1954. 115-122.

Earlier work using equinox noon values has shown a geomagnetic influence on the ionization in region F2. Consideration is here given to the geomagnetic influence evident in solstice midnight values. It is shown that at the solstices the form of the variation with geomagnetic

latitude may be quite different. An example is also given of conditions in December in which the noon values of the ionization for stations above about 30°N seem to show little or no geomagnetic effect. In the light of the results given, proposals are made for the distribution of new ionospheric sounding stations during the I. G. Y.
PA

BUSCH, H. F., and J. A. Green. An experiment with low-power ionosonde equipment. J. Geophys. Res. 68, 4375-4378 (1963).

Because of payload limitations, the advent of rocket-launched satellites designed to provide 'topside' ionospheric soundings has introduced the use of pulse sondes having effective radiated powers in the range of a few watts to tens of watts. The results of employing such instrumentation have been reported by Knecht and Russel [1962], Knecht and Van Zandt [1961], and Defence Research Telecommunications Establishment [1962]. The present note describes ground-based soundings obtained through use of radiated powers an order of magnitude smaller than those in the satellite experiments.

During March 1962 a field problem necessitated the measurement of local ionospheric behavior at a point near the geomagnetic equator where no regular synoptic data were available. In the interest of simplicity and portability, a pulse sounder was assembled from a collection of standard laboratory instruments. This sounder was successfully operated for a period of nine days. Figure 1 shows the equipment configuration so used. Fixed-frequency transmissions were conducted between 2.4 and 4.6 Mc/s at scattered intervals as appropriate to the expected layer height and critical frequency variations, although the sounder configuration itself was capable of being operated over a much broader frequency spectrum. A transistorized 'pocket-portable' signal generator featuring a 5-watt maximum peak pulse power output was used successfully as the RF source on occasion.
Excerpt

CAHILL, L. J., Jr., and J. A. Van Allen. New rocket measurement of ionospheric currents near the geomagnetic equator. J. Geophys. Res. 63, 270-273 (1958).

Using a nuclear free-precession total field magnetometer, a sudden change was observed in the shape of the total intensity v. height curve at about 97 km. This was best explained in terms of the entry of the rocket into a region where a current sheet exists.
PA

CALVERT, W., and R. Cohen. The interpretation and synthesis of certain spread F configurations appearing on equatorial ionograms. J. Geophys. Res. 66, 3125-3140 (1961).

On ionograms obtained near the magnetic equator the rectangular configuration called 'equatorial spread F' arises from scattering in the vertical plane (passing through the ionosonde) normal to thin, magnetic field-aligned irregularities located at or beneath the base of the F layer [Cohen and Bowles, 1961]. It is shown in the present paper that some strikingly different spread-F configurations on equatorial ionograms are due to irregularities of the same kind, but embedded in the F layer. Since these other configurations result from similar irregularities, the category of 'equatorial spread F' is generalized to include them. An 'ionogram' corresponding to scattering from an individual 'equatorial spread F' irregularity can be calculated. A composite ionogram resulting from a number of such scatterers can then be synthesized by superposition. By appropriate distributions of scattering centers in the east-west plane, many features of the 'equatorial spread-F' configurations observed on Huancayo ionograms can be simulated. This process of ionogram synthesis constitutes a new technique for the determination of (1) the height of patches of small-scale irregularities in the F region; (2) the horizontal distance of the patches from the ionosonde in the vertical east-west plane; (3) the thickness of the patches; (4) their east-west extent; and (5) the east-west component of their drift velocity. The patches are measured to have an east-west extent of up to 300 km and a thickness between 10 and 50 km. Their drift velocity is eastward, gradually decreasing from 200 to 100 meters/sec after 2100 hours local time.
A

CALVERT, W., K. Davies, and Father J. Koster. Doppler studies of equatorial flutter fading. IN: Semi-annual Report to Voice of America, Part B. Africa Ionosphere NBS Rept. 7276, National Bureau of Standards. Boulder, Colo. 103-118 (July 1962).

The purpose of this report is to describe some measurements of the frequency of radio waves received during conditions of equatorial flutter fading, and to advance a tentative physical explanation of this phenomenon.

At the suggestion of Dr. Davies, Father Koster carried out the experiment during September and October 1961 as part of a general study of radio propagation between Tripoli, Libya (transmitter) and Accra, Ghana (receiver). The 19.904 Mc/s transmitted frequency was controlled by a stable oscillator at Tripoli, and the received frequency was compared with that of a similar oscillator at Accra. In this manner, it was possible to detect the relatively small doppler shift imposed by the ionosphere and record it on slow-moving magnetic tape. Upon playing the tape at full speed (1500 times the recording speed) doppler shifts of a few cycles per second are transformed into audio frequencies acceptable to standard audio-frequency spectrum analyzers. Davies, Watts, and Zacharisen (1962) have discussed this technique in greater detail.

The analysis of the data was performed as a part of a study of equatorial spread F (Calvert, 1962). It is based on the interpretation that the flutter-fading signals are propagated by coherent scattering from the thin, magnetic-field, aligned irregularities which are associated with equatorial spread F (Cohen and Bowles, 1961).

Excerpt

CALVERT, W. Equatorial spread F. NBS Tech Note 145, National Bureau of Standards, Boulder, Colo. (1 Aug. 1962). AD-297 341.

Most equatorial spread F may be attributed to coherent scattering by thin, magnetic-field-aligned irregularities in the ionization of the F layer. These irregularities occur in patches which move horizontally. The velocity of the motion may be measured by (1) the simulation of spread F observed with a single ionsonde, (2) the timing of the occurrence of spread F at spaced ionosondes, or (3) the measurement of the doppler-shift imposed on scattered radio waves. The velocities are west-to-east throughout the night, with magnitudes of 100-200 m/s at sunspot maximum and 50-130 m/s at sunspot minimum. The instability of the F layer giving rise to the formation of spread-F irrigularities could result from (1) upward electromagnetic drift of the ionosphere as a whole, (2) thermal contraction of the neutral atmosphere after sunset, (3) atmospheric gravity waves, or (4) geomagnetic support of the F layer against gravity.

A

CALVERT, W., K. Davies, E. Stiltner, and J. T. Brown. Equatorial spread-F motions. IN: Proc. of the International Conference on the Ionosphere, London, July 1962. 316-322 (The Institute of Physics and the Physical Society, London, 1963).

The velocities of moving patches of equatorial spread-F irregularities were determined by the following three techniques: (1) examination of the changing spread-F configurations observed with a single ionosonde, (2) measurement of the Doppler shift of radio waves scattered by spread-F irregularities, and (3) timing of the occurrence of spread-F at spaced locations. The velocities were found to be west-to-east, decreasing in magnitude with the time of night. At sunspot maximum they range from 80 to 200 m/sec; at sunspot minimum, from 60 to 130 m/sec. Spread-F patches appear to last through the night, travelling from sunset to sunrise.
PA

CALVERT, W., T. E. VanZandt, R. W. Knecht, and G. B. Goe. Evidence for field-aligned ionization irregularities between 400 and 1000 km above the earth's surface. IN: Proc. of the International Conference on the Ionosphere, London, July 1962, 324-329 (The Institute of Physics and the Physical Society, London, 1963).

Two recent soundings of the topside of the ionosphere with rocket-borne sounders launched from Wallops Island have confirmed the existence of field-aligned ducts. On one flight, flown during spread-F, 50 ducts were encountered in the altitude range from 400 km to 1000 km. The median chord cut across these ducts was 1.4 km, and the separation between them was 1 km to 30 km.

The observations indicated that the atmospheric temperatures in the F region were 1150 ± 50°K around 1900 L. T. (24th June 1961) and 850 ± 30°K around 2400 L. T. (13th October 1961).
A

CALVERT, W. Instability of the equatorial F layer after sunset. J. Geophys. Res. 68, 2591-2593 (1963).

It is shown that the downward wind caused by the cooling of the upper atmosphere after sunset could give rise to the irregularities in the equatorial F region observed at that time. The observed cooling appears to provide the same degree of instability as that provided by electric fields on Martyn's theory.
A

CALVERT, W., and C. W. Schmid. Topside spread F. Paper presented to Commissions III and IV, URSI, Fall Meeting, Seattle, Washington, 10 Dec. 1963.

Ionograms recorded by the Alouette topside sounder satellite exhibit a variety of spread-F echo configurations. The observed echoes are found to be consistent with three qualitative radio-propagation models involving aspect-sensitive scattering by thin, magnetic-field-aligned irregularities, ducting along broad irregularities, and refraction within large-scale reductions of electron density. A large number of Alouette ionograms were examined for the spread-F configurations to determine their frequency of occurrence. Spread-F appeared on 54 percent of the topside ionograms, with the three types exhibiting markedly different patterns of occurrence in geomagnetic latitude and local time.
A

CARMAN, E. H., B. C. Gibson-Wilde, and R. J. Conway. Anomalous VHF trans-equatorial ionospheric propagation recorded at Townsville. Austral. J. Phys. 16, 171-176 (1963).

Since Ferrell (1951) first reported anomalous VHF propagation in equatorial regions, a number of workers have observed the phenomenon during the early afternoon and evening hours, especially the latter. Backscatter experiments in the neighbourhood of the Virgin Islands were carried out by Villard, Stein, and Yeh (1957) employing fixed-frequency radar sounders located at St. Croix and by Dueño (1960) from Mayagüez. Villard, Stein, and Yeh observed backscatter signals, at frequencies up to 46.2 Mc/s, corresponding to slant ranges up to 8000 km between 1500 and 2100 hr local time. These results were attributed to successive reflections from a tilted F layer without intermediate ground reflections (^{n}F propagation). Dueño investigated the long-range trans-equatorial (LRTE) echoes at frequencies up to 49.68 Mc/s over a two-year period. He found a marked seasonal variation in the occurrence, the maxima occurring during the equinoctial periods. Low angle of arrival of the signals was deduced.
A

CASAVERDE, M. Introduction to geomagnetism: The equatorial electrojet. Am. J. Phys. 29, 744-753 (1961).

The fundamentals of the measurement of the earth's magnetic field are described. Its general form is approximated to the field of a theoretical dipole magnet. The solar daily type (S) of transient variation in the geomagnetic field depends on the solar activity, the seasons, geographical latitude, and local time. At Huancayo Magnetic Observatory the abnormally high daily variation of the horizontal component of the field at the magnetic equator was discovered; it is confined to a narrow belt around the magnetic equator due to an induced effect of the equatorial electrojet. This equatorial electrojet is an eastward flowing current in the atmosphere at about 100 km altitude, some 660 km wide, with a measured maximum current density as high as 140 amp/km of width, for a given time. The theory of the origin of the electrojet, developing from an increase in atmospheric conductivity at the equator and winds at high latitudes, is described. Finally, the quiet-day solar daily variation in the vertical component of the geomagnetic field in the magnetic equatorial region in Peru is presented tentatively as a combined effect of the normal upper atmospheric current flow and the electrojet. A bibliography is included.
PA

CASAVERDE, M., A. Giesecke, and R. Cohen. Effects of the nuclear explosion over Johnston Island observed in Peru on July 9, 1962. J. Geophys. Res. 68, 2603-2611, (1963).

An account is given of observations in Peru associated with the nuclear explosion over Johnston Island on July 9, 1962. The observations discussed are principally those of magnetic and micropulsation activity resulting from the e. l. f. and hydromagnetic waves accompanying the explosion.
EEA

CASSELMAN, C. J., D. P. Heritage, and M. L. Tibbals. VLF propagation measurements for the Radux-Omega navigation system. Proc. IRE 47, 829-839 (1959).

This paper describes special VLF propagation measurements in connection with a feasibility study of a long range navigation system. Round-trip single-frequency measurement of phase stability was made between Hawaii and San Diego on frequencies from 10.2 kc to 18.2 kc in 1 kc increments. During Jan. 15 to 23, 1958, the standard deviation of phase

stability on 12.2 kc was 4 μsec daytime and 5 μsec night time. One-way two frequency transmissions were monitored in San Diego and Washington, D. C., to determine the phase stability of a 1 kc difference frequency for pairs of frequencies from 10.2 kc to 18.2 kc. Data analyzed at time of submission of this paper (10.2-16.2 kc) indicate limitations of the two-frequency system for lane identification (resolution of cyclic ambiguities corresponding to one period of the carrier frequency). The techniques used to instrument these tests are considered somewhat unique. Data reported herein are general and applicable to any propagation study. The data being collected are leading to a better understanding of the mechanism of VLF propagation.
N

CCIR. Atmospheric radio noise over tropical land masses. Indian report, Comite Consultatif Internationale de Radio Communication. Doc. 162-E, Xth Plenary Assembly, Geneva, 1963.

No abstract available.

CCIR. Special problems of HF radio communication associated with the equatorial ionosphere. IN: Documents of the Xth Plenary Assembly. International Radio Consultative Committ , II, 353 (International Telecommunication Union, Geneva, 1963).

CONSIDERING
that HF radiocommunications for paths which cross or follow close to the magnetic equator are known to experience certain difficulties associated with the equatorial ionosphere;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the phenomena peculiar to ionospheric propagation at or near the magnetic equator;
2. what are the effects of these phenomena on radiocommunication as a function of:
   - class of emission,
   - antenna characteristics,
   - frequency,
   - geographical location, orientation and length of propagation path,
   - time of day, month and phase of solar cycle;
3. what are the physical mechanisms involved?

Excerpt

C

CCIR. Propagation curves for VHF/UHF broadcasting in the African continent. Report 24. IN: Documents of the Xth Plenary Assembly, International Radio Consultative Committee II (International Telecommunication Union, Geneva, 1963).

1. Introduction

It is now well known, that radio field-strengths depend upon climatic conditions. The C.C.I.R curves (Recommendation 370) refer primarily to temperate continental climates and will therefore only apply in limited regions of the African continent. Although data for other types of climate are somewhat sparse, it is possible to give an estimate of the modifications to the above C.C.I.R curves required to make them applicable, at least approximately, to other parts of Africa.

2. African climates

For convenience Africa, has been divided into regions, as shown in Fig. 1, each of which corresponds to a fairly well defined type of climate. The classification is as follows:

1. Temperate (Mediterranean)
2. Desert (Saharan)
3. Sub-tropical (continental)
4. Sub-tropical (maritime)
5. Equatorial
6. Temperate (continental)

It should be noted that these divisions are somewhat arbitrary and that the classification of radio climates is not necessarily the same as that of meteorological climates even though the terminology is comparable. Furthermore, it is clear that the boundaries between the various regions will be ill-defined; and guidance on the estimation of propagation conditions for paths near to a boundary or covering more than one climatic region, can be obtained from Report 233. A precise definition of these climates depends on an average of available data. In the preparation of propagation curves, some random path-to-path differences have undoubtedly been ascribed to climatic differences. Each set of curves is, however, the best estimate available at present.

3. Presentation of curves

Figs. 2 to 37 present curves of field strength as a function of distance for the VHF/UHF broadcasting bands, and give for 50% of receiving locations the field strength exceeded for at least 50%, 10% and 1% of the time. The curves have been drawn for a power of 1 kW radiated from a half-wave dipole. In using these curves for practical planning, the general considerations contained in Annexes I and II to Recommendation 370 and in Report 233 may be considered applicable.

When a transmission path crosses one of the climatic boundaries, interpolation may be made between the curves corresponding to the two regions

proportionally (in db) according to the fractions of the path contained in each of the regions.

With respect to the VHF bands (450-1000 Mc/s), the experimental data contained in Doc. V/45 (France) of Geneva 1962, and the curves of Doc. 231 (France) of Geneva 1963, were normalized and extrapolated by theoretical methods, taking into account information about meteorological conditions in Africa.

The curves corresponding to the UHF band (Figs. 20-37) have been drawn for a frequency close to 700 Mc/s, considered representative of the whole of the band 450-1000 Mc/s, since the available experimental results are insufficient to justify separate predictions for different frequencies in the band.

With respect to the VHF band (40-250 Mc/s), experimental data for Africa are even less numerous. Measurements have been made by the French Administration at a frequency close to 100 Mc/s, but only along the west coast of Africa between approximately the 10th and 22nd parallels. The estimates for the VHF band were deduced from radiometeorological considerations and comparisons with data from other regions of the world.

It must be especially emphasized as regards curves for the VHF band (Fig. 2-19) that they apply only to propagation by tropospheric mechanisms. Particularly in equatorial regions, propagation by way of the ionosphere is important at the lower frequencies in the VHF band. It is therefore likely that higher field strengths will occur at long ranges, more often at frequencies below about 60 Mc/s than is indicated by the curves in this Report; and this factor must be borne in mind in planning broadcasting for such frequencies.

Excerpt

CCIR. Sound Broadcasting Television. Xth Plenary Assembly. International Radio Consultative Committee, V (International Telecommunication Union, Geneva, 1963).

This volume contains information on:

P. 45 E. 3 Tropical Broadcasting Recommendation 48 [Question 102 (XII)], "Choice of Frequency to Avoid Interference in Bands Shared with Tropical Broadcasting."

P. 45 E. 3 Recommendation 49 [Question 102 (XII)], "Choice of Site of Stations and Type of Antenna to Avoid Interference in the Bands Shared with Tropical Broadcasting."

P. 46 Recommendation 139 [Question 70, § 1], "Design of Transmitting Antennae for Tropical Broadcasting."

P. 47 Recommendation 140 [Question 70, § 3] "Design of Receiving Antennae for Tropical Broadcasting."

P. 47 Recommendation 214 [Question 102 (XII)], "Limitation of Power of Transmitters in the Tropical Zone to Avoid Interference in the Bands Shared with Tropical Broadcasting."

C

P. 48 Recommendation 215 [Questions 27 and 102 (XII)], Study Program 112 (XII, Recommendation 214), "Maximum Power for Short Distance High-Frequency Broadcasting in the Tropical Zone."
P. 50 Recommendation 216 [Question 102 (XII)], "Minimum Permissible Protection Ratio to Avoid Interference in the Bands Shared with Tropical Broadcasting."
P. 123 Report 301 [Question 156 (XII)], "Design of Transmitting Antenna for Tropical Broadcasting."
P. 145 Report 303 [Question 155 (XII)], "Determination of Noise Level for Tropical Broadcasting."
P. 149 Report 304 [Question 157 (XII)], "Fading Allowances for Tropical Broadcasting."
P. 152 Report 305, "Best Method for Calculating the Field-Strength Produced by a Tropical Broadcasting Transmitter."
PP. 233-243 Questions and Study Programmes Assigned to Study Group XII (Tropical Broadcasting): Opinions and Resolutions of Interest to this study group.

This section defines future work.

C

CHADWICK, W. B. Variations in frequency of occurrence of sporadic E. IN: Smith, E. K., and S. Matshushita, ed. Ionospheric Sporadic E, 182-193 (Pergamon Press, Inc., New York, 1962).

The question of the dependence of sporadic E on the sunspot cycle has been largely unresolved, with many investigators obtaining conflicting answers. In this chapter results are given covering daily-hourly values of fE_s for eleven years at three ionosphere-sounding stations, College, Washington, and Huancayo, chosen as representative of the three main sporadic-E zones. These stations experienced a minimum of equipment changes and changes of location during this period. Scaling procedures were monitored over the eleven years by a data quality-control group at the National Bureau of Standards. The period included the highest yearly average sunspot number for over 200 years.

Correlation coefficients for yearly count of $fE_s > 5$ Mc/s vs yearly average sunspot number were found to be: College, −0×68 (daytime only, −0×63); Washington, −0×52 (night only, −0×52); Huancayo, −0×42 (night only, −0×66). Various hourly and monthly correlations were obtained. Of the 150 correlation coefficients listed in the paper, 144 are negative.

An incidental outcome is the confirming of diurnal and seasonal trends at stations in the auroral, north temperate and equatorial zones, making use of many more data than hitherto available.
J. Res. NBS

CHAKRABARTY, S. K. Geomagnetic time variations and their relations to ionospheric conditions. Current Sci. India 15, 246-247 (1946).

Comparison of magnetic records at different observatories (San Juan, Alibag, Huancayo) show that the quiet day solar diurnal variations S_q at low but equal geographical latitudes differ widely in intensity and in type. They indicate a geomagnetic control rather than a dependence on geographical latitude. The possible connection of this fact with the dependence of maximum noon ionization of the F_2 layer on the geomagnetic latitude is noted. It is suggested that this layer may be the seat of the S_q current system.
PA

CHAKRAVARTI, S. P., P. B. Ghosh, and H. Ghosh. Atmospherics in radio broadcast reception at Calcutta. Proc. IRE 27, 780-783 (1939).

This paper relates to investigations extending from January to August, 1938, (including winter, summer, and rainy seasons) on atmospheric disturbance in medium- and short-wave bands (0.6 to 6 megacycles) prevalent in the eastern part of India. A suggestion has been made for broadcast transmission standards to be adopted in India on the basis of atmospheric field-strength measurements. Effective service areas of 1.5 kilowatts, 370 meters and 5 kilowatts, 235 meters, medium-wave broadcast transmissions have been estimated on the standards suggested.
A

CHAMBERS, C. On the luni-solar variations of magnetic declination and horizontal force at Bombay, and of declination at Trevandrum. Phil. Trans. A 178, 1-43 (1887).

In the early attempts to investigate the influence of the moon upon terrestrial magnetism, the observations dealt with extended over periods so limited that little was possible beyond determining the average character of the lunar dirunal variation. This was mainly because magnetic disturbance tends – and especially in extra-tropical regions – to mask the minute variations that depend upon the moon. The series of observations made at the Colâba Observatory, Bombay, and discussed in the present paper, extending over twenty-five years in the case of the declination and over twenty-six and a half years in the case of the horizontal force, possesses therefore the double advantage of being lengthy enough to secure an approximate elimination of such disturbance as is involved in it, even by combination of portions only of the whole body of observations.
A

CHAN, K. L. Study of short period variations in the ionosphere by means of instantaneous frequency measurements. Tech. Rept. 66, Electronics Laboratory, Stanford University, Stanford, Calif. (1962).

For over a year in 1960 and 1961, stable-frequency transmissions from Puerto Rico (18 Mc/s) and WWV (20 Mc/s) were simultaneously and continuously recorded at Stanford University, Stanford, California, and at the University of Washington, Seattle, Washington.

Frequency fluctuations of these signals, much larger than the inherent frequency fluctuations of the transmitting and receiving systems, are identified and categorized into four main types: (1) those due to the diurnal variation of the ionosphere, (2) those correlated with the rapid variations of the geomagnetic field, (3) those induced by solar flares, and (4) those due to traveling ionospheric disturbances.

During periods of sudden commencements and the main phase of geomagnetic storms, and geomagnetic micropulsations, short-period (1/2 to 5 min) frequency fluctuations are found to be correlated with geomagnetic-field variations, to a much finer time resolution than has ever been reported before. Furthermore, frequency fluctuations occurring on different transmission paths, separated by several hundred kilometers, are also well correlated.

C

Sudden frequency deviations (SFD's) induced by solar flares are studied in detail. The model adopted for analyzing SFD's and related theories on absorption, recombination and the shapes of SFD's are briefly described. The percentage of solar flares accompanied by SFD's is a function of the size (or class) of the solar flare and the solar zenith angle (or local time) but does not show dependence on the season of the year or the heliographic location of the solar flares. SFD's are found to be associated with centimeter-wave impulsive bursts, meter-wave fast-drift bursts, and solar-flare, high-energy X-ray bursts. They are clearly distinguished from other flare-associated ionospheric effects on radio waves.

Traveling ionospheric disturbances were identified by noting similar frequency fluctuations on four spaced transmission paths occurring with the appropriate time delays and in the appropriate order. Traveling ionospheric disturbances, thus detected, are rare (9 cases in 1600 hours of data during 7 months), of large scale (spatial length from 1300 to more than 2000 km), and of high speed (velocities from 1450 to about 2750 km/hr). It is suggested that these disturbances may have been launched by the same event giving rise to sudden changes in the geomagnetic field.

This technique of instantaneous frequency measurement proves to be a very useful tool for ionospheric research and my become a welcome addition as a standard operation in an ionosphere station.
Excerpt

CHAN, K. L., and O. G. Willard, Jr. Observation of large-scale traveling ionospheric disturbances by spaced-path high-frequency instantaneous frequency measurements. J. Geophys. Res. 67, 973-988 (1962).

The instantaneous frequency of WWV 20 Mc/s (Washington, D. C.) and that of a highly stable c-w signal at 18 Mc/s from Puerto Rico have been simultaneously and continuously recorded between October 1960 and September 1961 both a Stanford, California, and at Seattle, Washington. Traveling ionospheric disturbances have been identified by noting similar frequency fluctuations on the four transmission paths that have appropriate time delays and are in the appropriate order. Because of the wide separation of the paths, only large-scale disturbances moving at high speed could be detected. From 1600 hours of data (usually from 1600 to 0200 UT) between October 1960 and April 1961, nine traveling disturbances have been positively recognized. Velocities and spatial lengths are deduced in six of them assuming that these disturbances travel at a constant speed. Velocities range from 1450 to approximately 2750 km/hr, and spatial lengths from 1300 to more than 2000 km. The direction of travel cannot be determined accurately, but for all it is from north to south. On four occasions sudden frequency changes, correlated with sudden changes in the earth's

magnetic field, preceded the appearance of large-scale traveling disturbances. It is suggested that these disturbances may have been launched by the same event that gave rise to the sudden change in the earth's magnetic field.
A

CHANDRA, S., J. J. Gibbons, and E. R. Schmerling. Vertical transport of electrons in the F region of the ionosphere. J. Geophys. Res. 65, 1159-1175 (1960).

From the equation of continuity for free electrons, an expression is developed for the veritical transport velocity which can be evaluated, subject to some limitations from electron-density-height profiles. A few numerical computations of the veritical drift velocities determined for the four IGY stations Huancayo and Talara, Peru; Panama, Canal Zone; and Washington, D. C., are presented. It is shown that the velocity is predominantly downward during the night and upward during the day at the equatorial stations. There is an apparent phase reversal from summer to winter at Washington. The order of magnitude of the apparent phase reversal from summer to winter at Washington. The order of magnitude of the vertical-velocity amplitude is 25 m/sec. There is substantial agreement between the values calculated here from ionopheric data and those deduced from S_q data on the dynamo theory.
A

CHANDRA, S. Plasma diffusion in the ionosphere. J. Atmos. Terrest. Phys. 26, 113-122 (Jan. 1964).

Equations of motion appropriate to the conditions existing in the ionosphere are discussed with a view to examining the condition for ambipolar diffusion ($\vec{v}_e = \vec{v}_i$). It is shown that for quasi-equilibrium and isothermal conditions, the required condition for ambipolar diffusion is given by curl $\vec{v} \times \vec{B} = 0$. It is further shown that the assumption of ambipolar diffusion along the field lines leads to the trivial situation of hydrostatic distributions of electron density independent of latitude. These results are not in agreement with the general accepted view that diffusion of the plasma along the direction of the magnetic field can account for many geophysical phenomena in the ionosphere. This disagreement is attributed to the fact that the assumption of field-aligned plasma diffusion puts a constraint on grad n_e which has not been taken into

account by the previous workers. It is pointed out that the solutions of $\vec{v}_e$ and $\vec{v}_i$ in terms of the particle densities and temperatures are not possible without the knowledge of the electric field. The theoretical determination of the latter appears to be extremely complicated and it seems desirable to measure it experimentally.
PA

CHANDRASHEKHAR AIYA, S. V. Measurement of atmospheric noise interference to broadcasting. J. Atmos. Terrest. Phys. 5, 230-242 (1954).

This paper gives a general survey of the problem of atmospheric noise measurement and establishes, by a subjective method, a criterion for assessing the annoyance value of the noise to broadcast reception. There follows the development of an objective method of measurement and a comparison is made between these measurements and the subjective observations, etc.

Ten impulses per minute are estimated to have an annoyance value to the listener of broadcast programmes. Noise is classified into three types: (a) type A noise giving the impression of continuous noise, (b) type B noise coming as distinct impulses, and (c) type C noise, a special form of type B noise arising from local thunderstorms. The importance of bringing statistical considerations into the field of assessment of atmospheric noise interference is discussed and a procedure for the collection of data and its assessment for obtaining monthly values for a specific service, broadcasting, is described.
A

CHANDRASHEKHAR AIYA, S. V. and K. R. Phadke. Atmospheric noise interference to broadcasting in the 3 Mc/s band at Poona. J. Atmos. Terrest. Phys. 7, 254-277 (1955).

Systematic measurements of atmospheric radio noise at 2.9 Mc/s were taken at Poona (18.31 N, 73.55 E), during the hours, 18 to 23 I.S.T., for the whole year 1953 by a method previously described by one of the authors. The details of the experimental work and the analysis of the results are given in the paper. Noise data as required for broadcast services have been calculated. These new data have been compared with the estimates of noise as deduced from Circular No. 462 of the U.S. National Bureau of Standards and with the experimental results as reported in the Radio Research Special Report No. 26, London. Noise levels have

been estimated from lightning discharge data on the basis of the known distribution of thunderstorm activity over the globe and compared with measured values.
A

CHANDRASHEKHAR AIYA, S. V. Noise power radiated by tropical thunderstorms. Proc. IRE. 43, 966-974 (1955).

The common types of tropical thunderstorms are described. A synthesis is made of the available information on the subject. Hence, the essential peculiarities and electrical parameters of typical lightning discharges are deduced. These are utilized to explain the radiation that appears as radio noise. An expression is deduced for the average electric field due to a stroke in a flash. This is used to evaluate the power at the source that should correspond to the noise field strength as measured by the noise meter previously described by the author. The noise power is found to vary as the inverse square of the frequency and the expression obtained for the noise power is expected to be valid in the frequency range of 1-20 mc. The theoretical results are compared with values obtained by experiment. There is close agreement between the two.
A

CHANDRASHEKHAR AIYA, S. V., C. G. Khot, K. R. Phadke, and C. K. Sane. Tropical thrunderstorms as noise radiators. J. Sci. Indus. Res., 14B, 361-376 (1955).

Tropical thunderstorms are characterized mainly by lightning within clouds. Atmospherics result in the range 1-20 Mc/s. The range 1-10 Mc/s is investigated. Noises are classified according to acoustical effect, in loudspeaker. The evaluation is made difficult by the movement of thunderstorms. Three types of noise phenomena during thunderstorms are distinguished, depending on time of occurrence and intensity of growth and decay.

Frequency during different seasons is given. Thunderstorms over the sea seem to originate different noise characteristics.
MGA

CHANDRASHEKHAR AIYA, S. V., Noise radiation from tropical thunderstorms in the standard broadcast band. Nature, 17B, 1249 (1956).

Power in watts produced by a typical flash in a tropical thunderstorm is $45/f^2$ where f is frequency in Mc./s ($f>1$). Below this frequency only

the stepped leader of discharges to ground radiates any significant power. On this basis power is

$$\frac{16.2}{f^2} \Big/ \left(1 + \frac{\delta^2}{4\pi^2 f^2 \cdot 10^{12}}\right)$$

MGA

CHANDRASHEKHAR AIYA, S. V. Conversion data for atmospheric noise interference measurements. J. Sci. Indus. Res. 17B, 337-339 (1958).

Atmospheric radio noise, a source of interference to broadcasting, is measured by an objective noise meter and noise levels are deduced from such measurements. The noise meter is calibrated using continuous signals, modulated 30%, by a 400 cycle note. Theoretical calculations have shown that it is sometimes necessary to convert the noise data thus obtained to data corresponding to calibrations employing other levels of modulation. The equation required for such conversion has been deduced. Conversion data obtained experimentally agree with those deduced theoretically.
MGA

CHANDRASHEKHAR AIYA, S. V. Atmospheric noise interference to short wave broadcasting. Proc. IRE. 46, 580-589 (1958).

In order to determine the different parameters necessary for assessing the interfering effect of atmospheric noise to short-wave broadcasting, a systematic physical analysis is made of how the atmospheric noise impulse, as heard by the ear, arises and how it causes annoyance to the listener of broadcast programs. Hence, criteria are developed both for measurement and estimation of atmospheric noise. The paper thus provides the necessary additional physical background for the author's papers on "Measurement of atmospheric noise interference to broadcasting" and "Noise power radiated by tropical thunderstorms" but leaves the final conclusions and results of the two papers unchanged. Although the paper is thus restricted in scope, it is believed that the general principles emerging from the discussion should be of wider application.
A

CHANDRASHEKHAR AIYA, S. V. Atmospheric noise interference to medium wave broadcasting. Proc IRE. 46, 1502-1509 (1958).

A brief description is given of the typical tropical thundercloud and the electrical discharges associated with it. The discharge that contributes significantly to noise in the medium waveband is described in greater detail. There follows a systematic physical analysis of how the atmospheric noise

impulse as heard by the ear arises and how it causes annoyance to the listener of broadcast programs. Hence, criteria are developed both for the measurement and estimation of atmospheric noise in the band. The method of analysis is similar to the one adopted by the author in a previous communication on atmospheric noise interference to short wave broadcasting.

The results of the investigation are expected to hold over the frequency range, 0.23 to 2.5 mc.
A

CHANDRASHEKHAR AIYA, S. V. Average power of impulsive atmospheric radio noise. Proc. IRE 47, 92 (1959).

The object of this letter is to provide an addendum to the papers on atmospheric noise interference to short and medium wave broadcasting. Measured and estimated values of noise obtained by following the procedure described in the papers are directly useful for one service only, viz., broadcasting. A method is described here to convert such data into forms useful for other services also.
A

CHANDRASHEKHAR AIYA, S. V., and C. G. Khot. Atmospheric noise interference in the standard broadcast band at Poona. J. Sci. Indus. Res. 18B, 54-66 (1959).

A report of some of the investigations carried out at Poona on atmospheric radio noise in the standard broadcast band (0.535-1.605 Mc/s) are presented. Systematic measurements were taken at 0.62 and 0.93 Mc/s during the hours 1800-2300 I.S.T., from March 1955 to February 1956, by a method previously described by one of the authors [J. atmos. terres. Phys., Vol. 5, 230 (1954)]. A possible way of noise estimation is described and the actual estimates compared with measured values. In Appendix I are given the details of the equipment designed and used in the measurements and in Appendix II a comparison is made of the available estimates of atmospheric noise with the measured values.
PA

CHANDRASHEKHAR AIYA, S. V. Measurement and description of the characteristics of atmospheric radio noise. J. Sci. Indus. Res. 18B, 44-47 (1959).

On the basis of the experimental and theoretical investigations carried out by the author and his collaborators at Poona during the hours of peak activity of tropical thunderstorms, an attempt is made to find an answer to the question of the C.C.I.R., namely, what are the most easily measured

characteristics of terrestrial radio noise from which the interference to different types of communication systems can be determined?
PA

CHANDRASHEKHAR AIYA, S. V., K. R. Padmanabhan, K. R. Phadke, and C. K. Sane. Atmospheric radio noise levels at Poona in the 2.5 - 20.0 Mc/s band. J. Sci. Indus. Res. 18B, 47-55 (1959).

Noise data in a form which includes both the amplitude and time characteristics of atmospheric radio noise presented. The amplitude characteristics are given in terms of the r. m. s. noise field strength corresponding to the average power received per flash. The time characteristics are given in terms of the median, higher decile and lower decile values of the duration of the impulse which arises from a flash and of the minimum number of impulses per minute necessary to cause annoyance or impair intelligibility.
PA

CHANDRASHEKHAR AIYA, S. V. HF noise radiators in ground flashes of tropical lightning. Proc. IRE. 48, 955-956 (1960).

Previous analyses of this subject ignore ground flashes because 1) they constitute less than 10 percent of all discharges in the tropics, and 2) the noise power involved at HF is not significantly different from that of cloud discharges. This letter gives the results of an analysis for substantiating 2).
A

CHANDRASHEKHAR AIYA, S. V. Structure of atmospheric radio noise. J. Sci. Indus. Res. 21D, 203-220 (1962).

No abstract available.

CHANDRASHEKHAR AIYA, S. V., and B. S. Sonde. Spring thunderstorms over Bangalore. Proc. IEEE 51, (Nov. 1963).

A study of the flashing characteristics of thunderstorms can provide useful information of scientific interest and application value if all types of flashes could be recorded with equal satisfaction. One way of realizing this requirement is by utilizing the now known experimental result that all types of flashes are equally effective in radiating HF noise. This paper describes a technique based on this criterion for investigating the flashing characteristics of thunderstorms and deducing therefrom values of flash densities

and thunderstorm parameters such as storm life, number of cells developed during the lifetime of a storm, cell life, rates of flashing, etc. The results of such studies of spring thunderstorms over Bangalore are discussed.
A

CHAPMAN, S. The solar and lunar diurnal variations of terrestrial magnetism. Phil. Trans. A 218, 1-73 (1919).

Contents.

CHAPMAN, S., and T. T. Whitehead. The influence of electrically conducting material within the earth on various phenomena of terrestrial magnetism. Trans. Cambridge Phil. Soc. 22, 463-482 (1922).

CHAPMAN, S. The electric current systems of magnetic storms. Terrest. Mag. Atmos. Elec. 40, 349-370 (1935).

1. This paper continues my discussion of the average characteristics of the field of geomagnetic disturbances or storms, given in two previous papers which will be referred to a 1 and 2; the irregular part of magnetic

disturbance is not considered. A condensed representation of the main average features of magnetic storms is given in 1 (pp. 61-72) and 2 (pp. 242-264), and evidence is described which supports the view that the type of the field remains fairly constant throughout a considerable range of intensity for the field as a whole.

In 2 it is shown that certain electric current-systems in the Earth's atmosphere could produce a disturbance-field of the observed type (this will be called the D- or disturbance-field; the letter D is also used in terrestrial magnetism for the declination but I think no confusion need arise from its use in this further sense). These current-systems are indeed somewhat too simple, because so far as their high-latitude portions are concerned they apply less to the actual Earth than to an ideal Earth for which the magnetic and geographic axes coincide; but I believe that they constitute a useful first approximation to the more complicated (atmospheric) current-system appropriate to the real Earth.

Excerpt

CHAPMAN, S. The Earth's Magnetism (John Wiley and Sons, Inc., New York, 1939).

This Methuen's Monograph presents maps of the field and discusses variations. The first chapter begins:

THE MAGNETIC ELEMENTS

The presence of a magnetic field near the earth's surface is revealed most simply by its directive effect on a magnetized needle.

In a compass the needle is weighted so as to swing horizontally. It takes up a definite direction at each place, usually not agreeing with the geographical or true north; the deviation from true north is called the compass error, or (by mariners) the variation, or the declination (D); it may be eastward (and is then reckoned positive) or westward (negative). The end of the needle which, over most of the earth, points nearly northward, is called the north-seeking or positive end; the compass direction from the centre to this end is called the magnetic north, and the vertical plane through this direction is called the local magnetic meridian plane.

A needle perfectly balanced (before magnetization) about a horizontal axle placed perpendicular to the magnetic meridian, so that it can swing freely in this plane, is called a dip needle. After magnetization it takes up a definite inclination I to the horizontal; I, called also the magnetic dip, is reckoned positive if the north-seeking end points downward (as it does over most of the northern hemisphere).

The intensity of the magnetic force at any point is denoted by F, and H and V denote its horizontal and vertical components, both reckoned positive; the downward vertical component is denoted by Z, and has the same sign as I. The northern and eastern components of H are denoted

by X and Y, and may be positive or negative. All the quantities D, I, F, H, V, Z, X, Y are called magnetic elements; they are connected thus:

$X = H \cos D, \quad Y = H \sin D,$

$$\tan D = Y/X, \quad H^2 = X^2 + Y^2;$$

$H = F \cos I, \quad Z = F \sin I,$

$$\tan I = Z/H, \quad F^2 = H^2 + V^2 = X^2 + Y^2 + Z^2$$

To specify the field at a point three elements are needed – those commonly used are H, D, I; H, D, V; or X, Y, Z.
Excerpt

CHAPMAN, S. Notes on the lunar geomagnetic tide: I. Its mathematical and graphical representations, and their significance. Terrest. Mag. Atmos. Elec. 47, 279-294 (1942).

This paper supplements and comments on a recent valuable discussion of the geomagnetic tide or lunar daily geomagnetic variation L by J. Bartels and H. F. Johnston; this referred particularly to the geomagnetic tide in Huancayo horizontal magnetic force, but also extended the existing notation for L, and illustrated L by means of two new types of harmonic-dial diagram. The present paper is general in that it does not discuss results for L for any particular station or element; its chief novel feature is a further mode of representing L for any element and station, throughout half a lunation or any greater interval (ignoring seasonal changes), by means of a surface or by plane contour-lines representing the surface. The relations between various aspects of L hitherto considered, by Chambers, Broun, Figee, Bartels, Johnston, and others, are elucidated with reference to this surface.
A

CHAPMAN, S. The equatorial electrojet as detected from the abnormal electric current distribution above Huancayo, Peru, and elsewhere. Arch. Meterol. Geophys. Bioklimatol A 4, 368-390 (1951).

The abnormally large solar day range of the quiet day N component of the horizontal magnetic force at Huancayo, Peru (geomagnetic latitude – 0.6) compared with Madras, Java, etc. points to the daily rise and decline of an intense narrow eastward electric current there, superposed on the normal daily variation. It is also traced at Bombay and Manila. Author terms this the electrojet and calculates some provisional values for its intensity and width for alternative heights of 100 and 250 km.
MGA

CHAPMAN, S. The normality of geomagnetic disturbance at Huancayo. Geofis. Pura Appl. 19, 151-158 (1951). (In German.)

Evidence is adduced indicating that geomagnetic disturbance at Huancayo is normal, that is, comparable with that shown elsewhere in similar latitudes – as contrasted with the remarkable Huancayo abnormality, in the horizontal magnetic force, of the quiet-day solar and lunar daily variations and in the S_q augmentation (solar flare effect). The normality of magnetic disturbance at Huancayo is manifested by the disturbance daily variation S_D, and by the storm-effect D_{st}· and its associated changes of daily mean · (D_m) and the non-cyclic variation; it is not stated whether or not the irregular part D_i, is normal. The normality of D_{st} seems natural according to the Chapman-Ferraro theory of magnetic storms, but the normality of S_D is less easy to explain.
PA

CHAPMAN, S. Some phenomena of the upper atmosphere. Proc. Phys. Soc. B 64, 833-834 (1951).

The height distrubution of the atmosphere depends on the temperature and the mean molecular weight of the air; recent progress in our knowledge of these two quantities will be reviewed, the main sources of information being outlined. The motions (winds and tides) in the upper atmosphere will similarly be considered.

The main gross uncertainity regarding composition at high levels relates to the proportion of atomic nitrogen present. Besides the major constituents such as ozone, sodium and hydroxyl, which reveal their presence by their absorption or emission spectra; and there are others whose presence can be inferred from theirs.

The composition of the atmosphere changes by escape from the top (hydrogen and helium) and, by addition, from below (e.g. helium and carbon dioxide) and, as shown by the auroral spectrum, from above (hydrogen); cosmic rays also both add to the atmosphere and produce changes of composition by nuclear reactions.

Near the magnetic equator there are important ionospheric phenomena not yet fully explored and explained. Among these one of the most interesting is the abnormal intensification of electric current flow, specially notable over Huancayo in Peru.
A

CHAPMAN, S. The electro-jets. Proc. Mixed Commission on the Ionosphere, Canberra, Australia, 24-26 Aug. 1952, 88-91 (1953).

Short note suggesting ways in which the electric currents along the auroral zone may be determined, by measuring time rates of change of the gradients of the magnetic components.
PA

CHAPMAN, S., and K. C. Westfold. A comparison of the annual mean solar and lunar atmospheric tides in barometric pressure, as regards their worldwide distribution of amplitude and phase. J. Atmos. Terrest. Phys. 8, 1-23 (1956).

The solar and lunar semidiurnal atmospheric "tides" are compared as regards their worldwide distribution, on the basis of data from sixty-eight stations. Both these tides decrease with increasing latitude, but not quite symmetrically relative to the equator; there is some indication that in northern latitudes the lunar tide decreases rather more rapidly than the solar. Both tides are abnormally great over east Africa; the solar tide is also large in India, and the lunar tide in the East Indies. The lunar tide is large relative to the solar tide along and near the east coast of Asia, and also in the East Indies; it is small relative to the solar tide over India and western North America. The phase difference between the solar and lunar tides is specially large along and near the east Asiatic coast.
A

CHATTERJEE, B. Effect of magnetic field in oblique propagation over equatorial region. Indian J. Phys. 26, 297-312 (1952).

Computes curves of the propagation factor q versus the quantity x for oblique propagation in a magnetic field, under the simplifying assumption of transmission across the equatorial regions. Here x is 81 N/f^2, the electron density to squared frequency index. Lateral deviation is discussed, and computed for the special cases of Calcutta-Bandoeng, and Calcutta-Bombay.
M

CHATTERJEE, B. Studies on ionospheric absorption. Indian J. Phys. 26, 585-596 (1952)

This paper discusses briefly the phenomenon of ionospheric absorption of radio waves in their passage through the ionospheric regions. Results of observations made at Calcutta on the variation of ionospheric absorption with that of wave frequency are described. The results show that in addition to the losses due to collisions there is a marked increase in attenuation near the critical frequencies of the layers due to partial penetration of the wave energy. Presence of sporadic E layers also causes increased attenuation of F echoes by partial reflection and scattering. When there

is magneto-ionic splitting, the extraordinary component is always found to suffer higher attenuation as predicted by theory. On certain nights presence of sporadic D's was noticed. This caused high absorption on all frequencies in the short wave range. The sporadic D's are found to be associated with sporadic E and thunderstorms.
A

CHATTERJEE, B. Nature and origin of sporadic E regions as observed at different hours (over Calcutta). J. Atmos. Terrest. Phys. 3, 229-238 (1953).

The paper describes the results of measurement on the variation of reflection co-efficient of the sporadic E echoes and of the statistical study of the variations of amplitude of the same, carried out, over a period of 8 months (March to October, 1952) at the Ionosphere Laboratory of the University of Calcutta. It has been possible from these measurements and studies to discriminate between two types of E_s ionizations – thin layer type and ion cloud or blob type – causing the echoes. It was found that there is predominance of different types of ionizations at different hours of day and night. Thus in 78.6% of the cases observed in the early morning hours, the E_s ionization was of the cloud or blob type of structure. It is suggested that this type owes its origin to ionization by sporadic meteors which are most frequent in the early morning. During the period of sunrise in the E layer, thin layer type of ionization were found in 83.7% of the cases. Such ionization is probably caused by the production of a sharp ionization density gradient at the bottom of the E layer, due to photo-detachment of electrons from negative ions of 0 and 0_2 by sun's rays coming from below the horizon. The most common type of E_s ionization in the afternoon and evening hours was found to be a mixture of the thin layer and ion cloud types. These owe their origin to travelling ion clouds coming from above. Observations also showed that E_s ionization (of the mixed type, with a slight preponderance of the thin layer type) was associated with thunderstorms. Blanketing types of E_s are also observed during thunderstorms. Occasionally, some thin layer types of ionizations were also observed in the morning, a few hours after sunrise. The origin of these ionizations seems to be due to some modifications of the E layer structure.
A

CHATTERJEE, B. Some regularities of the ionospheric F region. J. Geophys. Res. 58, 353-362 (1953).

It has been shown recently by Ratcliffe that, although the behaviour of the critical frequency (and hence the maximum ionization density) of the F2 region is very irregular, that of its total ion content (in a column of unit cross-section) is much less so. However, the regularities observed

by Ratcliffe are confined only to a few stations and disappear when the F1-F2 bifurcation is large. It is shown in the present paper that if, instead of the total ion content of the F2 region, that of the F2 cum F2 region (n_T) is considered as a whole, then the regularities become much more marked. Further, the regularities are found to persist for all the three stations considered — Slough (northern hemisphere), Falkland Islands (southern hemisphere), and Singapore (equatorial region) — even when the bifurcation is large. Certain peaks, however, are found to occur on the otherwise smooth variations of the monthly mean values of n_T. These are explained as due to tidal effects. The paper also shows that the observed regularities of the composite F region are in conformity with the recent hypothesis that F1 and F2 belong really to one ionized region, being produced by a common ionizing radiation from the sun.
A

CHATTERJEE, B. Ionization distribution in the F-region. Indian J. Phys. 28, 53-66 (1954).

Computes F-region ionization distribution assuming scale height increases with height and recombination coefficient decreases with height. Finds ionization distribution curves including tidal-drift effects agree with observation. Thinks F1 and F2 are produced by common ionizing source.
M

CHATTERJEE, B. Regularities in the F-region of the ionosphere. Nature 173, 263-264 (1954).

Ratcliffe has shown that the total F2-layer ionization content varies more regularly with solar zenith angle than does the maximum density. Chatterjee finds that even greater regularity results from using the total ionization content of F1 and F2 combined. The implication is made that F1 and F2 have a common ionizing source. The variation with latitude of the monthly mean noon value of total ionization content does not show the equatorial dip characteristic of the maximum density; the peak of the total ionization content curve is found at zero geomagnetic, rather than geographic, latitude.
M

CHATTERJEE, B. Some comments on "The solar control of the E and F1 layers at high latitudes." J. Geophys. Res. 59, 435 (1954).

Says that Calcutta E-layer critical frequency data taken on the manual recorder are contaminated with E_s.
M

CHATTERJEE, B. A discussion on the variation of F-region height. J. Geophys. Res. 60, 325-327 (1955).

Variations of F2-region height with season and solar activity have been explained in terms of the author's picture of ionization distribution in the F region. Different types of behaviours of F2-region height at different latitudes are accounted for with the presently accepted model of temperature distribution in the upper atmosphere.
A

CHERNOSKY, E. J., and E. Maple. Geomagnetism. IN: UAAF Geophysics Directorate. ed. Handbook of Geophysics, 10-11 (Macmillan Co., New York, 1961).

The charts of the magnetic field and its components from which Figures 10-9 through 10-14 were taken represent the best present knowledge of the "main field" (or the "permanent" magnetic field) over the surface of the earth. These charts are published every five years. They are derived from periodic determinations of the absolute values of the field and its components at the permanent magnetic observatories (less than one hundred) located rather irregularly over the earth and from supplementary observations, made by field parties at intervals of a few years, to cover the areas away from the magnetic observatories. The slow change with the years of the main field (the "secular change") which amounts at most to about one-tenth of one percent per year of the total field, is also indicated on the charts which are prepared by the U.S. Navy-Hydrographic Office from geomagnetic data supplied by the U. S. Coast and Geodetic Survey.

The accuracy of the present charts depends upon how well the various portions of the earth are covered by the magnetic surveys. In some areas, such as the United States, they are probably accurate to about one per cent, (declination accurate to about 1/2 degree) but in less accessible areas the error may be considerably larger, particularly at high latitudes. Also, small surface anomalies of about 100 miles extent or less are not indicated on the charts and may, in some cases, amount to a few per cent of the total field.

The measurements of the main field which are used in the charts are made in such a way as to eliminate, as far as possible, the effects of time variations of field (discussed in Section 2) which arise outside the earth.

Recently, airborne magnetometers (of the "flux-gate" or "second-harmonic" type) which are capable of rapid and precise surveys of the

earth's field and its components have been put into use. Proton precession magnetometers, which measure F only, are also used.

The results of extensive aerial surveys, together with improved methods of analyzing the data, would make possible more accurate, detailed, and up-to-date magnetic charts.
Excerpt

CHILTON, C. J., A. H. Diede, and S. M. Radicella. Transequatorial reception of a very-low-frequency transmission. J. Geophys. Res. 69, 1319-1328 (1 April 1964).

A comparison is made between the phase and amplitude of the 18-kc/s signal NBA (Balboa, Panama) recorded at Boulder, Colorado, in the northern hemisphere and Tucumán, Argentina, in the southern hemisphere. Although these two propagation paths are essentially the same length, the difference between them in the diurnal change in phase height is approximately 5 km, and the estimated field strength appears to be significantly lower at Tucumán than at Boulder. It is suggested that the cause of these observed differences is the latitudinal variation in ionization due to cosmic rays.

CLEMESHA, B. R., and R. W. H. Wright. Scattering of radio waves in the ionosphere. Tech. Note 2, Ghana University, Africa (6 Jan. 1962).

A theoretical study of the scattering of medium frequency radio waves in the lower ionosphere, demonstrating that the maximum in scattering observed in the region of 70 Km does not require the postulation of a maximum in electron density or intensity of irregularities at that height.
STAR

CLEMESHA, B. R. A rotating aerial back-scatter sounder. Tech. Note 4, Ghana University, Africa (10 Aug. 1962).

Description of a back-scatter sounder designed for the investigation of irregularities associated with equatorial spread F.
STAR

CLEMESHA, B. R., G. S. Kent, J. R. Koster, and R. W. H. Wright. Equatorial study of irregularities in the ionosphere. Summary Rept. 2, Oct. 1961 - Dec. 1962, Ghana University, Africa (1 March 1963). AD-410 983.

A number of experiments which were designed to investigate F region irregularities by means of the back-scatter technique are described. The experimental techniques are described briefly, and the results given in detail. The results show the seasonal and nocturnal variations in the occurrence of irregularities which scatter 18 Mc/s. signals, the size and drift velocity of patches of irregularities, the height at which the irregularities occur, and the motion of the irregularities, as opposed to the motion of the patch. The results are discussed in the light of information obtained by other workers using different techniques.
DDC

CLEMESHA, B. R. The elongation of irregularities in the equatorial ionosphere. J. Geophys. Res. 68, 2363-2366 (1 May 1963).

A correlation analysis of spaced aerial fading measurements for medium-frequency radio waves scattered from the D and E regions at a location near the magnetic equator is reported. The results show that there is a slight tendency towards field-aligned elongation of the diffraction pattern on the ground for echoes from 80 and 90 km and considerable elongation for echoes from above 90 km. It is shown that ambipolar diffusion processes would become anisotropic at this height, which could lead to the elongation of the irregularities in the ionosphere responsible for the diffraction pattern on the ground.
A

CLEMESHA, B. R. Back-scatter of radio waves from the equatorial F region. Nature 199, 797-798 (24 Aug. 1963).

Investigation of the irregularities giving rise to equatorial-type spread-F, using a backscatter radar operating on a frequency of 18 Mc. Echoes are recorded which could not have been caused by the mechanism of ionospheric reflection and ground scattering. The range spread of the echoes indicates that the irregularities occur in patches with east-west dimensions of approximately 100 km. Briefly compared are the occurrence of direct backscatter at 18 Mc and the presence of equatorial-type spread-F on ionograms. It is suggested that the irregularities responsible for direct backscatter are similar to those which cause the flutter fading and Doppler shift of obliquely propagated signals.
IAA

CLEMESHA, B. R. An investigation of the irregularities in the F-region associated with equatorial type spread-F. J. Atmos. Terrest. Phys. 26, 91-112 (1964).

The results are given of an investigation of spread-F irregularities, using a backscatter radar operating on a frequency of 18 Mc/s. The irregularities are shown to occur in patches which extend over distances of up to 400 km in the E-W vertical plane. Seasonal and nocturnal variations in the occurrence of irregularities are given, and it is shown that variations in their height closely follow variations in the height of the F-layer. The drift velocity of patches of irregularities is shown to be of the order of 100 m/sec towards the east. The results of Doppler shift measurements are interpreted as indicating that the irregularities sometimes exhibit large vertical velocities. It is shown that the irregularities are anisometric in the E-W vertical plane, and appear to have a maximum scattering cross-section in the direction perpendicular to their direction of motion.
A

COHEN, R., and K. L. Bowles. On the nature of equatorial spread F. J. Geophys. Res. 66, 1081-1106 (1961).

Ionospheric propagation via scattering from the F region was sought at 50 Mc/s over a transequatorial path (with midpoint near Huancayo, Peru) employing a 2580-km transmitter-receiver separation. Propagation via F scatter was present over this path about 10 percent of the time, though only at night. A condition closely related to the occurrence of F scatter was the presence of equatorial spread-F configurations on the Huancayo ionograms. The height of the propagation medium supporting this F scatter was usually identifiable with the lowest height of the associated equatorial spread F on the ionograms. On the basis of an interpretation of experimental results, equatorial spread F is shown to arise from scattering by relatively thin sheets of irregularities in electron density which occur at the bottom of the F layer or as much as 100 km lower. The thickness of these patches is estimated at the order of 50 km. The scattering irregularities comprising these patches are found to be elongated along the earth's magnetic lines of force. Electron irregularities of scale 10 meters or smaller measured in at least one dimension transverse to the magnetic field lines, and 1000 meters or longer measured along the magnetic field lines, are shown to exist as high as 450 km in the nocturnal equatorial F region during equatorial spread-F conditions. Equatorial spread-F echoes observed at Huancayo are demonstrated to be arriving at all elevation

angles in the magnetic east-west plane. The geographical extension of a given scattering sheet in the magnetic east-west direction was at times as great as 1000 km. An observational procedure is suggested for distinguishing two fundamental varieties of spread-F echoes appearing on the equatorial ionograms. A necessary condition, that the contours of mean electron density be parallel to the magnetic lines of force, is proposed as a controlling factor for the occurrence f spread F in the equatorial ionosphere.
A

COHEN, R., K. L. Bowles and W. Calvert. On the nature of equatorial slant sporadic E. J. Geophys. Res. 67, 965-972 (March 1962).

Two features of the daytime sporadic-E echoes observed on ionograms obtained near the magnetic equator were termed "equatorial sporadic E" and "equatorial slant sporadic E". These are traces that project from the E-layer trace and have equivalent ranges independent of frequency and proportional to frequency, respectively. Radar studies in Peru indicate that a thin stratum of magnetic-field-aligned irregularities embedded in the E-layer is responsible for the entire sporadic-E configuration. The increased equivalent ranges of the slant trace are attributed to oblique propagation in the east–west plane orthogonal to the irregularities. By accounting for the refraction and retardation imposed by the E-layer, the entire configuration can be simulated in detail. It is established from this analysis that the equatorial electrojet flows within the equatorial E-layer, and that its first-order current variations are coherent over distances of 500 km or more along the magnetic equator.
A

COHEN, R. Introduction (International Symposium on Equatorial Aeronomy). J. Geophys. Res. 68, 2359-2361 (1963).

The accompanying papers were among those presented at the first International Symposium on Equatorial Aeronomy, held at Hotel Huaychulo, near Huancayo, Peru, from September 18 through 25, 1962. A summary session was held in Lima on the morning of September 27, 1962.

The field now known as 'equatorial aeronomy' refers to studies of the atmosphere in the vicinity of the magnetic equator. In particular, inasmuch as charged particles interact with the earth's magnetic lines of force, the geometry of the equatorial magnetic field leads to many interesting ionospheric and magnetic phenomena. Many workers all over the world have been studying the equatorial ionosphere for some time. Although considerable information has been accumulated, many mysteries still remain. However, there had never been a conference devoted exclusively to equatorial

aeronomy (as there had been for polar aeronomy, for example). The need for such a conference was recognized in 1959, and this symposium was held three years later.

The objectives of the meeting were threefold: (1) to arrive at an understanding of what was known in each area of the field of equatorial aeronomy, (2) to decide what important problems were still outstanding in each area, and (3) to propose individual and collective programs for solving some of these problems and filling gaps in the present knowledge. Some 60 persons actively engaged in equatorial studies attended, about half of whom were from observatories and laboratories in the vicinity of the magnetic equator. The countries represented were Argentina, Bolivia, Brazil, Chile, Colombia, Ethiopia, France, Ghana, India, Japan, Kenya, Mexico, Nigeria, Peru, the Phillippine Islands, the United Kingdom, the United States, and West Germany.
Excerpt

COHEN, R., and K. L. Bowles. The association of plane-wave electron-density irregularities with the equatorial electrojet. J. Geophys. Res. 68, 2503-2525 (1963). Similar material was presented to Commission III, URSI Fall Metting, Ottawa, Canada, 17 Oct. 1962.

The field-aligned irregularities responsible for the 'equatorial sporadic E' configuration on equatorial ionograms have been established to be plane waves of electron density aligned with the magnetic field but moving perpendicularly to it. It has been generally realized that there is some connection between these irregularities and the equatorial electrojet. This paper demonstrates that the irregularities are spatially and temporally correlated with the equatorial electrojet. First, it is shown experimentally that the irregularities occur in the height and latitude region in which the electrojet flows; i. e., they are embedded in the electrojet. Second, it is shown that there are temporal correlations between the intensity of radio waves scattered from the irregularities associated with the electrojet and the horizontal intensity of the earth's magnetic field, a measure of the electrojet current. The scattered intensity is imperceptible until a certain 'threshold' of electrojet current is reached. As the electrojet current increases above the threshold, a scatter signal suddenly rises above the noise, increasing abruptly at first, then gradually. This threshold suggests that the plasma wave irregularities are generated by the current stream. According to the theory of Farley such a threshold can be interpreted as the onset of a plasma instability in the equatorial electrojet, leading to the formation of plasma waves. It is shown that by means of the intensity of the signal scattered from the electrojet irregularities, together with magnetometer measurements, it may be possible to estimate from ground observations the daytime field variation resulting from disturbance currents at great distances from the earth.
A

COHEN, R., and K. L. Bowles. Ionospheric VHF scattering near the magnetic equator during the International Geophysical Year. J. Res. NBS 67D, 459-480 (1963).

General results and statistical studies of equatorial VHF oblique ionospheric scatter signals are presented for one calendar year of the International Geophysical Year. The equatorial scatter signals were usually stronger than their counterparts at temperate latitudes. Scattering was observed comparable to the D-region scatter propagation familiar elsewhere, but usually the E-region scatter predominated. Scattering via F-region irregularities was observed at nighttime over a 2580 km path centered about the magnetic equator.

The intense daytime equatorial E-region scattering was established to be largely due to irregularities associated with the equatorial electrojet. Its communications potentialities appear promising for paths having mid-points within a 10° band of latitude centered about the magnetic equator.

When the D-region scattering was distinguishable, it usually appeared to be stronger than that over similar paths at temperate latitudes. However, during the daytime over a path centered just at the magnetic equator, this comparison is just the opposite.

Relatively strong scattering from irregularities in the E region was also observed at nighttime, with the result that the weakest signals received diurnally over the equatorial paths were comparable to the strongest signals propagated over similar paths at temperate latitudes.

Both the daytime and nighttime scattering via E-region irregularities exhibited an asymmetry about the magnetic equator, being stronger for a path midpoint 5° south of the magnetic equator than for a midpoint a similar distance to the north.

A

COOK, C. J., and D. C. Lorents. Electron collision frequencies and scattering cross-sections in the ionosphere. Final Tech. Rept. 6, Contract DA-36-039 SC-85052, SRI Project PAU-3340 Stanford Research Institute, Menlo Park, Calif. (15 Aug. 1961).

Stanford Research Institute is attempting to construct a computer model that will rapidly calculate the effects of natural or man-made ionospheric disturbances on a communication system or net from a priori knowledge of the disturbing event. To do so, three major items must be available:

1. There must be an accurate model of the effects that the disturbance produces upon the ionosphere in terms of microscopic details of the species as a function of spatial position.

2. From this information the conductivity tensor must be calculated and presented in a form that can be utilized by a computer routine.
3. A computer model must be available to calculate the communication net's behavior.

Our primary task was to supply information on the collision cross sections and frequencies required for the calculations and to indicate their accuracy.

From the microscopic point of view, calculations of the conductivity tensor $\|\sigma\|$ for the normal ionosphere as a function of height is not expected to differ in principle or techniques from calculation of $\|\sigma\|$ for a disturbed ionosphere. In both cases it is necessary to know the electron spatial density and velocity distribution, the spatial density of the atomic, molecular, and ionic species, and their velocity-dependent electron momentum transfer cross sections, $Q_d(v)$. Because only numerical details of the calculation depend upon the specific model used, and since the conductivity of the normal ionosphere above the D region has not been established, the normal ionosphere was studied.

The literature pertinent to the calculation or measurement of electron momentum transfer cross sections, $Q_d(v)$, was next analyzed, and the best values for the appropriate cross sections were selected and their accuracy estimated. The velocity-dependent electron collision frequency was established for the major species of the ionosphere. Scattering cross sections are defined and discussed in detail in this report because the apparent confusion of their types and values indicated to many investigators that they must be the source of error in conductivity.

However, during the course of these investigations, it became evident that the major source of discrepancy between observed and calculated conductivities (or collision frequencies) of the normal ionosphere could stem directly from the use of inappropriate approximate forms for $\|\sigma\|$. For example, a large error could be made in many experiments by employing the usual Appleton-Hartree equation. Since this approximation to $\|\sigma\|$ is used extensively in ionosphere studies, it was deemed necessary to determine the conditions under which an expression of the Appleton-Hartree form was valid. To do so it was necessary to consider the derivation of $\|\sigma\|$ so that the approximations and assumptions included in the final expression could be brought to light. For this reason, the derivation is included in this report.

It is not difficult to determine the correct form of $\|\sigma\|$ in the Appleton-Hartree sense: In the simple isotropic case

$$\sigma_{LM} = \frac{ne^2}{m}\left(\frac{\nu_{eff} - i\omega_{eff}}{\nu_{eff}^2 + \omega_{eff}^2}\right).$$

However, both the effective collisional frequency ν_{eff}, and wave rotational frequency, ω_{eff}, are integral functions of the velocity-dependent electron frequency, $\nu_m(v)$, the wave rotational frequency ω, and the velocity distribution. Unfortunately, known conditions under which ν_{eff} and ω_{eff} can be simply expressed in terms of an average collision frequency $< \nu >$ and ω are very limited, as is subsequently shown. For those interested in propagation through the ionosphere it would be of great value if appropriate approximations could be found that would permit retention of $< \nu >$ and algebraic forms for $\|\sigma\|$: The work initiated in this study should be continued.

Finally, the results of these calculations were applied to the model of the normal ionosphere. Assuming a Maxwellian electron velocity distribution, the average and effective collision frequencies of the ionosphere were determined as a function of altitude. Extension of this work to a disturbed ionosphere rests upon the availability of an adequate model of the event.

Since ν_{eff} and ω_{eff} are dependent upon $\nu_m(v)$, thus $Q_d(v)$ and ω, the attenuation coefficient, index of refraction and phase shift as a function of altitude and ω have not been calculated. However, the limiting forms of ν_{eff} and ω_{eff} for $<\nu> \ll \omega$ and $<\nu> \gg \omega$ are presented in the text and these macroscopic parameters for these cases can be simply calculated from the usual expressions derived from Appleton-Hartree based calculations.
Excerpt

CORY, T. S. Scale-model measurements on a sloping-wire antenna. Research Memo. 4, Contract DA36-039-AMC-00040(E), SRI Project 4240, Stanford Research Institute, Menlo Park, Calif. (June 1963).

Radiation patterns of a 1:100-scale model of an end-fed sloping-wire antenna have been measured. The model antenna was made to simulate a tactical HF (3-to-8-Mc) communication antenna used with the AN/TRC-77 radio set. Such an antenna is of particular interest for tactical jungle communications where near-vertical propagation is pertinent rather than ground-wave.

The actual antenna, in addition to the sloping radiator, comes with two 50-foot counterpoise radials separated by 90 degrees on the ground. Since the model was measured in the presence of metal ground surfaces, the effect of the counterpoise on the radiation patterns is not shown. Because the radiator itself is electrically short (0.076-0.203 λ), the counterpoise is expected to improve the radiation efficiency and to have a minimal effect on the radiation patterns.

On a scale-model basis, it is difficult to be more precise about the patterns than is indicated in this report, because of the difficulty in scaling

ground constants. It is possible to measure the free-space patterns of a symmetric sloping-wire structure in free space and reflect this mathematically into a ground geometry that may be controlled. This latter approach is currently being investigated, along with an experimental program to determine the location of effective ground with respect to the earth's surface. As near-veritcal radiation is of primary interest, the geometrical optics approach of ground reflection is expected to yield useful answers. Near grazing for vertical polarization, the geometrical optics technique breaks down, and the reflection must be considered as a diffraction problem.

The geometry of the antenna pattern measurements is shown in Fig. 1 The sloping-wire-antenna patterns were measured in the presence of a plane metallic reflecting ground, as is shown in Fig. 2 and in the presence of a 25-degree conical hill, as shown in Fig. 3. Elevation-plane patterns were obtained for two orthogonal polarizations. The sloping wire is shown in Fig. 4.
Excerpt

CORY, T. S., and W. A. Ray. Measured impedances of some tactical antennas near ground. Research Memo. 7, Contract DA36-039-AMC-00040(E), SRI Project 4240, Stanford Research Institute, Menlo Park, Calif. (Feb. 1964).

The dipole antenna was the most thoroughly investigated of the three. Its driving point impedance decreased as expected by the image method, with decrease in height until the height was reached where the end of the dipole approximately subtended the Brewster angle. The driving point impedance then increased rapidly for very low heights. A driving point impedance increase with low height was observed for the other two antennas as well.

For dipoles and large horizontal loops at low height above ground the image method calculations of impedance are insufficient. In like manner the treatment of the slant wire as a monopole fed against ground is also insufficient. As an example, the slant wire as recommenced in the AN/TRC-77 manual is improperly designed for transmitting efficiency.
A

COWLING, T. G., and R. Borger. Electric conductivity of the ionospheric D-region. Nature 162, 143 (July 24, 1948).

We have recently begun to investigate theoretically how atmospheric tidal motions should vary with height above the E-layer. The work is still

in the exploratory stage, and too great reliance cannot be placed on the tentative results which have so far been obtained. These results, however, suggest that tidal motions should increase with height for some considerable way above the E-layer. Considerable phase-changes may also occur above the E-layer. Such results are difficult to incorporate into a general theory of the magnetic variations, and we do not claim to be able to do so: but Dr. Martyn's interpretation of the facts need not be the only possible one.

Dr. Martyn's final suggestion will, unfortunately, not wholly resolve the difficulties to which we directed attention. Polarization counters the magnetic reduction in conductivity fully only if the Hall currents are completely prevented from flowing, and in this case the polarization field must considerably exceed the original field which makes it arise. If, say, the Hall currents in the ionosphere were vertical, the polarization produced by accumulations of charge above and below the conducting layer would be only slowly dissipated, and would be able to build up to a size sufficient to produce the desired effect. But normally the polarization electric field has a horizontal part, which makes the polarization charges leak away as fast as they collect. Hence, while polarization may partially restore the reduction in conductivity due to the magnetic field, it cannot do so more than partially.
Excerpt

COWLING, T. G. The electrical conductivity of the ionosphere. International Council of Scientific Unions. Proc. Mixed Commission on the Ionosphere, Canberra, Australia, 24-26 Aug. 1952, 106-109 (1963).

Chapman's dynamo theory of lunar geomagnetic variations proves that conductivity of ionosphere is $2.5 \times 10^5/f$. Recent research shows that conductivity arises in equatorial regions mainly from lower part of E layer. According to Hüono, there is enhanced conductivity near the magnetic equator due to polarization mechanism. According to Schluter, the total electric force can be divided into original electric force and secondary electric force. His analysis cannot be applied to ionosphere due to the presence of large numbers of neutral atoms.
MGA

CRACKNELL, R. G. Transequatorial propagation of VHF signals. QST 43, 11-17 (Dec. 1959).

In general, the TE path is between areas on either side of the geomagnetic equator and 1500 to 2500 miles away from it. It is effective during the hours of darkness, and on frequencies up to 1.5 times the observed daytime maximum

usable frequency for F-layer propagation. Optimum propagation conditions occur at the time of the equinox, between points in the same longitude, located about 2000 miles from the geomagnetic equator.

The TE mode may be usable between locations where the direct line between the two stations cuts the geomagnetic equator at an angle as low as 45 degrees, and beyond the distance limits mentioned above, but moving away from the most favorable spots causes both the reliability and the maximum usable frequency to drop off. The quality of the modulation on a TE-propagated signal is often distorted by a characteristic flutter fading. The signal is good enough for communication purposes, but the mode is unlikely to be of value for broadcasting or television. The transmitter power required to produce an intelligible signal is small. A few watts of r.f. in a vertical quarter-wave aerial may induce a signal of one microvolt or more in a similar aerial located 4000 miles away in the opposite TE zone. Excerpt

The author took a comprehensive look at this propagation mode from the potential user standpoint, estimating MUF, zones of coverage, seasonal effects, reliability, quality, noise levels, backscatter, and possible physics of propagating modes.
C

CRACKNELL, R. G. More on transequatorial propagation. QST 44, 47 (Aug. 1960).

The author describes angle of arrival and time delay of signals propagated via the transequatorial mode. He postulates three modes: (1) 2-hop F2, using maxima in electron density at ±10° magnetic latitude, (2) F type TE (super mode) which "comes off the electron gradient at the shoulder and shoots straight across to the other side," and (3) true TE, which uses the high-density zones as a lens. He states that the high-density zones are unstable and "regions of flux and turbulence productive of large inhomogeneities," . . . "This is the primary cause of flutter, but the severest flutter is caused by mixing of the three modes of propagation, each with its distinctive delay."
C

CRAIG, L. H. Panama VHF and HF jungle propagation. U. S. Army Electronics Research and Development Lab., Ft. Monmouth, N. J. (Nov. 1963).

In hilly, mountainous, forested country, VHF communications are much better than expected. More extensive VHF tests should be conducted in tropical terrain to obtain conclusive coverage data. These tests show that it is reasonable to expect complete reliable coverage of an area 25 miles in diameter by using a balloon antenna 200 to 400 feet high at the command post with the patrol antenna raised on a 100-foot lightweight, blow-up mast. The steep, sharp, high, tropical hills are an advantage in most cases to VHF propagation. Laboratory tests of the J. string-type antenna are in progress, and a light-weight, 100-foot long blow-up mast to support it is being procured for feasibility tests. A better way to package the 6-ounce, lightweight cable such as is used for a 100-foot measuring tape is required. The PRC-25 is too heavy if it has to be carried 25 miles on jungle trails. A lightweight set similar to the PRC-35, but less the four-channel mechanism would be more useful if the 25 mile distance is actually a firm requirement.

For HF, low power, less than 10 watts using vertical-incidence for the E layer reflection in the daytime is dependable. The use of shortened, quick-erectable, horizontal antennas is feasible. Interference is the only reason that communications are difficult. The low frequency end of HF sets should start at 2 Mc/s or lower, not 3 Mc/s, and above 8 Mc is not useful for 25-mile circuits. Efficient antennas are a help but operators having procedures to change frequencies and quick, easy tuning methods are more essential. The center-fed matching system is the most useful because it can be used for both short antennas and half-wave antennas with the least matching and tuning trouble. At night, from 2000 hours to 0600 hours in the morning, the frequency must be below 2.5 Mc/s and a half-wave, efficient antenna must be used. The GRC-9 is too heavy for foot patrols. A special low-frequency range, 5-to-10-pound set is needed unless foot patrols do not need to walk 25 miles. A variable inductance, blow-up coil for use in antenna matching circuits would be more useful than the present coil types.
Excerpt

CRICHLOW, W. Q., R. T. Disney, and C. A. Samson. Atmospheric radio noise summary for the period June 1 through Nov. 30, 1957. NBS Rept. 5556, National Bureau of Standards, Boulder, Colo. (20 Feb. 1958).

The first article is a summary report of noise measurements made during the period June 1 through Nov. 30, 1957 by stations in the recording network

C

which is supervised by the National Bureau of Standards. Stations engaged whole time or part of the period were as follows: Boulder, Colo.; Bill, Wyo.; Front Royal, Va.; Marie Byrd Base, Antarctica; Balboa, Canal Zone; Ibadan, Nigeria; Thule, Greenland. Studies in this field are intended to produce more specific recommendations for future noise predictions.
N

CRICHLOW, W. Q., R. T. Disney, and C. A. Samson. Atmospheric radio noise for the period Dec. 1, 1957 through Feb. 28, 1958. NBS Rept. 5580, National Bureau of Standards, Boulder, Colo. (23 June 1958).

In the second article, radio noise measurements during the period Dec. 1, 1957 through Feb. 28, 1958 have been summarized for the following stations: Boulder, Colo; Bill, Wyo.; Front Royal, Va., and Balboa, Panama Canal Zone. Details of data analysis show the existence of contamination from signals, man-made noise, and receiver noise. A procedure adopted to eliminate these effects and to obtain a "best estimate" of a true atmospheric noise level at each station is described. Differences between the predictions and observations are discussed by time blocks.
N

CRICHLOW, W. Q., (Chairman of committee). Special report on characteristics of terrestrial radio noise. Subcommittee of Commission IV, URSI, (Aug. 1960).

Although there are many types of noise that cause interference to reception, this study has been directed toward atmospheric noise, which is the principal natural source of interference at frequencies below about 30 Mc/s. This type of noise, which originates in thunderstorms throughout the world, is very erratic in character and varies over wide limits as a function of a number of variables. The principal ones are geographic location, radio frequency, time of day, and season. Some of these variations are systematic and some are random and must be treated statistically. It is convenient to separate the variations with time into intervals of various lengths. Let us consider first the short-term variations.

For sampling times of several minutes to about an hour, many of the important statistical properties of atmospheric noise remain essentially constant, except during local thunderstorms. The shorter-term fluctuations in amplitude have been described by several investigators by the use of amplitude-probability distributions which show the percentage time for which the noise envelope exceeds various levels (see Section 5.6). This type of presentation is convenient for investigating the interference caused by a particular type of noise to an existing communication service, as well as for designing new systems to operate in the presence of a given type of noise.

From hour to hour during the day, both the level of noise and the shape of the probability distribution change because of changing propagation conditions and frequency of thunderstorms, but fortunately these variations tend to follow a particular pattern. Over most of the frequency range the highest levels occur at night, because noise is then propagated by means of the ionosphere from storms at large distances. During the daytime, ionospheric absorption reduces the noise from distant storms, but at some frequencies the noise level is enhanced by local storms during the afternoon. Thus, we have maximum noise levels at night, minimum during the morning, a moderate increase in the afternoon, and again high levels at night. At the higher frequencies in the HF range, the shape of the diurnal curve tends to reverse itself, because the ionosphere will support propagation only during the daylight hours.

From day to day, at a particular time of day, there are variations in the received noise level due to variations in propagation conditions and in thunderstorm activity. These day-to-day variations can also be conveniently treated by means of probability distributions as in the case of the short-term fluctuations.

There is also a systematic seasonal trend in the noise which is influenced by ionospheric absorption as well as by the location and number of thunderstorms. The thunderstorm centers tend to shift north and south of the equator from summer to winter. In addition, the ionospheric absorption is higher in the summer, which tends to offset the increased thunderstorm activity at that time; nevertheless, the received noise tends to be highest in the summer and lowest in the winter at tropical and temperate latitudes.

The received noise level varies with frequency, because the noise radiated by the thunderstorm and the efficiency of its propagation are functions of frequency. In general, the received noise level decreases with increased frequency.

There are variations with geographic locations, the highest levels being encountered in equatorial regions and the lowest levels in the polar regions. The received noise levels are influenced by topography as well as by weather and propagation conditions. Some variation with sunspot activity may also be expected.

Excerpt

CROMBIE, D. D. On the mode theory of very-low-frequency propagation in the presence of a transverse magnetic field. J. Res. NBS 64D, 265-267 (1960).

The effect of a purely transverse horizontal magnetic field on the propagation of very-low-frequency (VLF) waves is considered. It is shown that the magnetic field introduces nonreciprocity, and that for propagation along the magnetic equator, the rate of attenuation is less for west-to-east propagation than for east-to-west propagation.
MGA

CROMBIE, D. D. Reflection from a sharply bounded ionosphere for V. L. F. propagation perpendicular to the magnetic meridian. J. Res. NBS 65D, 455-463 (1961).

There is experimental evidence that v. l. f. signals propagating from west to east suffer less attenuation than from east to west. Earlier work treating the case of nonreciprocal propagation along the magnetic equator is extended in latitude. The nonreciprocity shown by $\|R\|$ for highly oblique propagation along the magnetic equator persists when the reflection point moves towards a magnetic pole, but at the pole itself $\|R\|$ is reciprocal. To a first approximation $\perp R \perp$ is reciprocal at all magnetic latitudes. The conversion coefficients $\|R\perp$, $\perp R\|$, are greater for east-to-west propagation than for propagation in the opposite direction, except at a magnetic pole where they are equal.
EEA

CROMBIE, D. D. Nonreciprocity of propagation of V. L. F. waves along the magnetic equator. Proc. IEEE 51, 617-618 (1963).

An explanation for the nonreciprocity of v.l.f. propagation along the magnetic equator has been given by Barber and Crombie [J. Atmos. Terrest. Phys., Vol. 16, No. 1-2, 37-45 (Oct., 1959)]. They implied that the reason for the reduced reflection for waves incident from the east was due to increased dissipation of wave energy in the ionosphere. In this note Crombie states that this is no longer believed to be true, that the absorption coefficient in the ionosphere is independent of the direction of incidence, and that the nonreciprocal reflection is balanced by a non-reciprocal transmission coefficient at the ionospheric boundary.
EEA

CROOM, S., A. Robbins, and J. O. Thomas. Two anomalies in the behaviour of the F2 layer of the ionosphere. Nature 184, 2003-2004 (1959).

A geomagnetic anomaly is observed in the distribution of electron density with magnetic latitude at noon at the equinox. A trough in the distribution is found at the magnetic equator which becomes broader at lower levels in the F region. A diurnal asymmetry is found in the electron density measured at a given height. The density at nearly all latitudes at 09 hours is greater than that at 15 hours for heights above about 200 km, with the opposite effect below 200 km.
PA

CSIR. Ionospheric data (for March 1962). Council of Scientific and Industrial Research, Radio Research Commission, New Delhi (1962).

Regular ionospheric observations are being taken in India in a chain of eight stations, seven of which are in the 75° E longitude zone, covering a range of geomagnetic latitudes from 19.2° N to 0.9° S. This document is a coordinated publication of the ionospheric data of all these stations, with data on actual propagation conditions, and such geophysical data as are of interest for ionospheric studies.
STAR

Apparently these data reports were published monthly.

CSIR. Ionospheric predictions for January and February 1963. Council of Scientific and Industrial Research, Radio Research Commission, New Delhi (Sept. 1962).

East Zone predicted median values for the ordinary ray critical frequencies and maximum usable frequencies for 4000 km for January and February 1963 are given.
STAR

Apparently these predictions were published monthly.

CSIR. Ionospheric predictions, September 1963. Council of Scientific and Industrial Research, Radio Research Commission, New Delhi (May 1963).

Charts showing the September 1963 ionospheric predictions for: (1) median values for the ordinary ray critical frequencies, F_2 in Mc/S, for zone E, and (2) median values for the maximum usable frequencies (4000), F_2 in Mc/S, for zone E, are presented. A nomogram for transforming F_2-zero-MUF and F_2-4000-MUF to equivalent maximum usable frequencies at intermediate transmission distances and a conversion scale for obtaining optimum traffic frequency are also presented.
STAR

CYNK, B. Variations in the disturbance field of magnetic storms. Terrest. Mag. 44, 51-57 (1939).

Chapman's investigation has been extended by using more stations and data. Between the N and S auroral zones 14 stations in various latitudes were used. Chapman's conclusion that the form of the disturbance field due to the storm-time disturbance field (D_m) was generally independent of the intensity of the magnetic disturbance over considerable ranges of activity, was confirmed. It was found that (1) the storm field was stronger at practically all latitudes during the equinoctial months March, April, Sept., and Oct., than at others, (2) the H component of D_m was nearly twice as great in the local winter as in the local summer season, and (3) the averages for the year and equinoxes of the geographical distribution of the H component of D_m are approximately symmetrical about the geomagnetic equator. Thus the D_m field has a part symmetrical about the equator together with a sinusoidal part. The average characteristics of the sinusoidal part are examined.
PA

DAGG, M. Diurnal variations of radio-star scintillations, spread F, and geomagnetic activity. J. Atmos. Terrest. Phys. 10, 204-214 (1957).

An equipment has been constructed to enable a long-term investigation to be made of the temporal variations of radio star-scintillations. A year's observations are presented in terms of the monthly average diurnal variations of spread F and geomagnetic activity.
A

DAGG, M. The origin of the ionospheric irregularities responsible for radio-star scintillations and spread-F--II. J. Atmos. Terrest. Phys. 11, 139-150 (1957).

A theory is presented which attributes the occurrence of ionospheric irregularities in the F-region to turbulent wind motion in the dynamo region at a height of 110-150 km. The resulting turbulent component of the electric potential field produced is communicated to the F-region, as suggested by Martyn (1955), where magneto-electric forces then cause the ionization to form eddies. It is suggested that the absence of daytime scintillations is due to the inhibition of turbulent flow by large temperature gradients during the day. The theory is then compared in detail with observations and shown to be capable of explaining all the major features of radio-star scintillations, together with such diverse results as the long-term correlation of scintillation amplitude with magnetic activity and the variation in the occurrence of spread-F and scintillations at different parts of the earth over the sun-spot cycle.
A

DANIELS, F. B., and S. J. Bauer. The ionospheric Faraday effect and its applications. J. Franklin Inst. 267, 187-200 (1959).

An outline is given of the theory of the ionospheric Faraday effect (the rotation of the plane of polarization of radio waves by the ionosphere). Measurements of ionospheric characteristics by means of lunar radio reflections and radio transmissions from artificial satellites utilizing this effect are discussed. The rate of fading of satellite signals due to the Faraday effect is found to depend upon both the integrated electron density up to the height of the satellite and the local electron density at the satellite. Thus, a possibility exists of determining both quantities provided the satellite transmissions are received simultaneously by two or more stations. Expressions for the fading rate are derived and the effects of orbital parameters on the determination of ionospheric characteristics are discussed.
A

DAS GUPTA, M. K., and R. K. Mitra. Solar activity and the occurrence of E_s. J. Atmos. Terrest. Phys. 24, 408-411 (1962).

Extensive studies have been made in the past on the incidence of E_s ionization in relation to solar activity, but it appears that no definite correlation between the two has yet been established (Appleton and Naismith, 1940; McNicol and Gipps, 1951; Mitra, 1952; Smith, 1955; Rawer, 1955; Thomas, 1956; Penndorf and Coroniti, 1958; Kasuya, 1958; Ratcliffe, 1960). Recently we have examined the matter utilizing data collected over the years 1953-1959, which includes the IGY period. We were prompted to choose this period for our investigation for the following reasons: (1) a large number of stations with much improved ionosonde recorders came into operation during the IGY period making available a vast amount of data, and (2) the activity of the present solar cycle was more pronounced than the previous ones.

In all data from thirty-three stations in different regions (IGY Classification, 1959): Auroral—10; Subauroral—8; Minauroral—12; and Equatorial—3 were critically examined. Percentage occurrences of E_s (percentage of times $fE_s > 5$ Mc/s) at 1200 hours local mean time were plotted month by month for the sunspot maximum year (1957-1958) as well as for the sunspot minimum year (1954) for all these stations. Out of these, curves for twenty-four stations clearly indicate that the percentage occurrences were much greater in the sunspot maximum year than those of the minimum year. A representative plot is shown in Fig. 1(a). Out of the remaining nine stations, curves for four indicate a definite decrease in E_s occurrences in relation to sunspot activity as shown in Fig. 1(b); whilst curves for five stations are rather doubtful showing neither increase nor decrease, as shown in Fig. 1(c). It also interesting to note that most of these curves show a marked seasonal effect, percentage occurrences of E_s being maximum during the local summer months as in Fig. 1(a, b). In some cases, however, there is also evidence of a minor secondary maximum during the local winter months.

The increased occurrences of E_s during the sunspot maximum year in the majority of cases strongly indicate a positive correlation between E_s occurrence and solar activity. The correlation is more strikingly evident in Figs. 2(a) and 2(b). Fig. 2(a) shows a plot of 12 monthly running averages of percentage occurrences of E_s ($fE_s > 5$ Mc/s) at Inverness along with that of Zürich relative sunspot numbers over the period 1953-1959. Fig. 2(b) shows a plot of 12 monthly running averages of percentage occurrences of E_s ($fE_s > 5$ Mc/s) for the same station versus that of the Zürich relative sunspot activity. From our preliminary analysis done so far it may be concluded that this is also true for majority of the stations. However, similar curves for all the stations mentioned above, as well as the evaluation of the exact nature of correlation between the two phenomena, are under detailed analysis and will be reported in due course.

DASGUPTA, P., and K. K. Vij. Statistical analysis of fading of a single down-coming wave. J. Atmos. Terrest. Phys. 18, 265-275 (1960).

The paper deals with the statistical analysis of fading of a single wave reflected (vertically) from the F-region of the ionosphere. These fading records are usually random and their amplitude distribution has been found by other workers to be Rayleigh, Gaussian or log-normal. The present analysis shows that the amplitude distribution is Rayleigh only in the case of rapid fading, whereas for slow and quasi-periodic fading it is found to represent what can be termed as an M-type. The distribution of successive differences in the amplitudes has also been studied; for a Rayleigh amplitude distribution this time analysis gives rise to a Type-VII distribution of Pearson as originally pointed out by Mitra (1949b) while in the case of M-type amplitude distribution it becomes Gaussian. Following Mitra's analysis, the rms value of the random velocity, v_0 of the ionospheric irregularities has been calculated from the time analysis. The value of v_0 has also been calculated from the autocorrelation coefficient of the amplitude R following Booker et al. (1950). The two values of v_0 thus obtained are compared and are found to agree well.
A

DATTA, R. N. Some studies on the spread-F, double-F and forked-F traces as observed at Haringhata (Calcutta). Indian J. Phys. 34, 482-492 (1960).

From the spread-F records and from the theoretical relation of the spread-F index with the critical frequency and the velocity of irregularities, it is found that the percentage of occurrence of spread-F depends both on the electron density and the velocity of the irregularities. The night-time appearance of this phenomenon and its sharp decrease at sunrise lend support to this conclusion.
PA

DATTA, S., and R. N. Datta. Gyro-frequency in the ionospheric regions. Indian J. Phys. 33, 316-324 (1959).

Gyro-frequencies in E, F1 and F2 regions over Haringhata, were calculated from measurements of ordinary (f_0) and extraordinary (f_x) critical

frequencies. Findings include the following: 1) magnetic fields were higher than those expected from extrapolation of the magnetic field at ground level to the heights of the regions by inverse cube law. 2) The marked semi-diurnal variation of the gyro-frequency of the E region reaches minimum at midday. 3) No such variation found in F1 nor F2, average winter value of the latter exceeds the summer value by 9%. 4) $f_x - f_0$ depends on high frequency values being lower than those at lower levels, as may be expected in quasi-transverse propagation.
N

DATTA, S., P. Bandyopadhyay, and R. N. Datta. Ionospheric observations on the F-region during the solar eclipse of April 19, 1958. J. Atmos. Terrest. Phys. 16, 182-185 (1959).

Effects of the eclipse derived from observations at the Ionosphere Field Station at Haringhata of the Institute of Radiophysics and Electronics, University of Calcutta, are presented. Investigations of variations of maximum electron density and of the F2-layer peak are illustrated by three diagrams. Only some indications of the appearance of an F1 peak could be obtained. An additional peak in F1 1/2, as shown on its ionogram, is probably not an eclipse effect.
MGA

DAVIES, K., J. M. Watts, and D. H. Zacharisen. A study of F2-layer effects as observed with a Doppler technique. J. Geophys. Res. 67, 601-610 (1962).

Changes in the height and shape of the ionosphere produce, at a receiver, variations in the frequency of waves emitted from a stable sender. WWV-10, WWV-15, WWV-20 and WWVH-10 have been recorded at Boulder on slow-moving magnetic tape. By rapid playback the Doppler frequency is converted into an audio frequency and the spectrum is analyzed by conventional techniques. Records obtained by this technique are presented to illustrate the phenomena observed during magnetically quiet and disturbed periods. Experimental effects associated with solar flares and magnetic sudden commencements are presented. The frequency dependence of the frequency variations is shown to give information about the height location of the associated ionospheric effects.
A

DAVIES, K. The measurement of ionospheric drifts by means of a Doppler shift technique. J. Geophys. Res. 67, 4909-4913 (1962).

A letter to the editor directing attention to work on ionospheric drifts being carried on at the National Bureau of Standards, Boulder, Colorado. The technique involves the spectral analysis of radio signals reflected from the F layer with almost vertical incidence. Examples are given of conditions during quiet and disturbed periods and methods of calculating vertical and horizontal movements are discussed. Spaced receiver and magnetoionic data are used and velocities are found which are of the order of 200 to 300 meters per second.
J. Res. NBS

DAVIES, K. and E. Stiltner. A study of maximum observed frequencies for the path Tripoli to Accra. IN: Semi-annual Report to Voice of America, Part B, NBS Rept. 7276, National Bureau of Standards, Boulder, Colo., 39-51 (July 1962).

One of the objectives of the stepped-frequency experiment carried out over the Tripoli to Accra circuit is the comparison between observed maximum frequencies (MOF) and the maximum frequencies given by various prediction systems.

The prediction methods used in the present comparison are those of the Central Radio Propagation Laboratory, namely:

(1) Ionospheric data obtained at Tamanrasset, some 350 km from the mid-point of the path, together with a Smith transmission curve (Circular 462).
(2) The numerical mapping method (Gallet and Jones 1960).
(3) CRPL, D series.
(4) World maps of F2 critical frequencies and maximum usable frequency factors (Zacharisen 1959, 1960).

The MOF was scaled as the highest frequency observed on the oblique ionograms. The reason for this choice is that the so-called "classical MUF," the estimated frequency at which the high-angle and low-angle rays merge (see Agy and Davies 1959), was often difficult to determine. In any case, the classical MUF may have little or no meaning from the communications point of view because there is no discontinuity of signal there.
Excerpt

DAVIES, K., R. M. Fisher, and E. Stiltner. Studies of ionospheric radio propagation over the path Tripoli to Accra using a step-frequency ionosonde. IN: Semi-annual Report to Voice of America, Part B, Africa Ionosphere, NBS Rept. 7276 National Bureau of Standards, 52-102 (1962).

The purpose of this paper is to present and discuss the experimental results of an oblique-incidence ionosonde experiment carried out from September 10, 1961 to October 15, 1961 over the 3300 km path between Tripoli, Libya, and Accra, Ghana. The ionosonde technique has been used extensively with normal incidence but relatively infrequently with oblique incidence because of synchronization problems. The frequency change-pulse method is almost essential in ionospheric sounding when it comes to identifying the many paths by which signals propagate between a sender and a receiver.

This technique had not previously been used in low latitudes, and one of the reasons for carrying out this work was to examine the mode structure of radio signals propagated via the ionosphere near the magnetic equator where large distortions and peculiar propagation effects are known to occur [Smith and Finney 1960].
A

DAVIES, K., and E. Stiltner. A study of the observed effects of solar flares observed on a trans-Sahara path. IN: Semi-annual Report to Voice of America, Part B, Africa Ionosphere. NBS Rept. 7276, National Bureau of Standards, Boulder, Colo. 119-134 (July 1962).

The Doppler technique, which was used to study the fading of high-frequency radio signals [Davies, Watts and Zacharisen, 1962] over the 3300 km path between Tripoli, Libya, and Accra, Ghana, has proven to be very useful in studies of the ionospheric effects of solar flares [see for instance, Davies 1962 a]. During the recording period September 11 to October 14, 1961 a number of events were noted which coincided with the times of optical solar flares. It is the purpose of the present contribution to discuss these solar flare events: first, in relation to other ionospheric phenomena and second, in terms of the heights at which flare-induced ionization is produced in the ionosphere.

The measurements in question were made on a carrier of frequency of 19.904 Mc and consisted of the recording at Accra, on magnetic tape moving with a speed of 0.02 inches per second, the beat frequency signal produced by the received carrier and a local off-set oscillator of high stability. For analysis, the beat frequency (of about 3 cps) is converted into an audio tone by rapid playback (30 inches per second) and the frequency spectrum is analyzed by conventional audio analyzers. The outputs of the analyzers thus consist of a frequency versus time record.
A

DAVIES, K., and E. Stiltner. Radio strength observations over the path Tripoli-Accra. IN: Semi-annual Report to Voice of America, Part B, Africa Ionosphere, NBS Rept. 7276, National Bureau of Standards, Boulder, Colo., 135-140 (1962).

As part of a more general study of ionospheric radio propagation over the path Tripoli-Accra signal strength recordings were made on two frequencies: 19.904 Mc and 49.76 Mc. The transmitters (continuous wave) were located in Tripoli and the receivers in Accra (distance 3300 km) and measurements were made over the period September 10 to October 15, 1961. The output of the transmitters were both near one kilowatt and the bandwidths of the receivers were set at 300 cycles per second. The minimum detectable signal was thirty decibels below one microvolt at 50 ohms.

It is the purpose of this contribution to discuss the results of this experiment and to compare them with the values to be expected on the basis of certain prediction systems.

A

DAVIES, K. The importance of wave polarization on the propagation of medium frequencies in low latitudes. IN: Semi-annual Report to Voice of America, NBS Rept. 8226, National Bureau of Standards, Boulder, Colo., 23 (March 1964).

The purpose of this paper is to offer some explanations to certain medium frequency phenomena observed near the magnetic equator. These observations were made recently in Africa as part of the joint NBS-USIA Africa ionosphere studies and consisted of the recording of the signal strength of the Nigerian transmitter at Kaduna, Nigeria, on a frequency of 940 kc/s. These results are reported by A. F. Barghausen in Contribution No. 1, and will not be considered in detail here. Briefly, the observations showed that during the hours of darkness the sky wave signal, from the vertically polarized transmitting antenna, was much weaker to the east and west than to the north.

Excerpt

DEARDEN, E. W. The geometry of radio reflections from field-aligned ionization irregularities in the ionosphere. Scientific Rept. 3, Contract AF64(500)9 Queensland University, Australia (Oct. 1961). AD-286 376.

Chapman's Auroral Geometry (J. Atmospheric Terr. Phys.) is generalized for an arbitrary angle of incidence of a radio wave on a geomagnetic field line. A method for dealing with refraction is described; in this case the results are illustrated by describing the echo surfaces for a transmitter located at Brisbane.

A

DEARDEN, E. W. Field aligned ionization irregularities. An investigation of echoes observed from Brisbane. Scientific Rept. 13, Contract AF64(500)9 Queensland University, Australia (March 1962). AD-294 723.

Ionization irregularities in the ionosphere, elongated along the direction of the geomagnetic field, were postulated by several workers, (e.g. Peterson et al. 1955), to account for scattering phenomena observed when the ionosphere is illuminated with radio waves from a transmitter, using a rotating directive aerial. It was suggested that reflections tend to occur when the ray path of the wave intersects the long axis of the irregularities, and hence also the direction of the geomagnetic field at normal or near-normal, incidence.

A

DEB, A. C. Penetration of thin ionospheric layers. Indian J. Phys. 14, 451-457 (1940).

Calculates wave reflection and penetration for thin parabolic layers. Finds complete penetration does not occur at critical frequency because of failure of geometrical optics.

M

DEGAONKAR, S. S. Changes in the electron density distribution in the ionosphere over Ahmedabad associated with solar flares and magnetic storms. Proc. Indian Acad. Sci. A 54, 24-35 (July 1961).

Describes changes in the F region electron density profiles during a disturbed period. Hourly values of peak electron density and total electron content below the peak are given.
PA

DEGAONKAR, S. S., and R. V. Bhonsle. Ionospheric disturbances and change in cosmic radio noise absorption on 25 Mc/s at Ahmedabad associated with some solar events and geomagnetic storms in Nov. 1960. J. Phys. Soc. Japan 17, 286-292 (1962).

Describes the results of analysis of N (h) profiles and the changes in the observed total attenuation of 25 Mc/s cosmic radio noise recorded at Ahmedabad during Nov. 10-17, 1960, a period of high solar activity. Using N (h) data and the available models of electron density variation with height above h maximum, calculations of ionospheric attenuation on 25 Mc/s cosmic ray noise are made and compared with the observed total attenuation of cosmic ray noise. It is shown that major attenuation takes place above h maximum and that during solar cosmic magnetic storms, the attenuations become abnormally low. The solar cosmic noise absorption recorded on Nov. 11, 1960 at Ahmedabad is shown to be the likely cause of the solar cosmic magnetic storm on Nov. 12, 1960. Reference is made to a similar event recorded on 30 Mc/s riometer at Ottawa on Nov. 12, 1960. This solar cosmic noise absorption was also followed by irregular long duration solar bursts. The Ottawa record shows in addition the presence of a polar cap type of absorption. These are now attributed to the bombardment of the upper atmosphere by low energy cosmic ray particles.
MGA

DELOBEAU, F. $F_{1,5}$ stratification at Dakar and motion of the sun. Compt. Rend. 235, 1573-1675 (1952). (In French.)

The F region of the ionosphere contains normally (during the day) 2 distinct layers—the F and Fe layers. A supplementary stratification, called $F_{1,5}$ by the French Service of military ionospheric forecasting, appears often in the subtropical regions. The hours of its presence and its importance vary from hour to hour and day to day during the year and

its existence causes a notable reduction of the degree of maximum ionization of both F layers. The author aims to show evidence of the influence of diurnal and seasonal periodicities upon the law of frequency in time. Graphs for the period July 1949—July 1952 showing the number of appearances of $F_{1,5}$ during summer, winter and the equinoxes, and its annual variation for Dakar are presented. Similar surveys have already been given for Singapore (1949). The author concludes that if the existence of $F_{1,5}$ can be explained by large-scale movements of ions over the equatorial zone—it seems that their regime differs according to regions and that there is reason to assume an influence of magnetic characteristics. Similar results obtained at numerous stations would reveal the effect of these characteristics.
MGA

DELOBEAU, F., and R. Gallet. The anomalous amplitude of seasonal effects in the equatorial ionosphere and the structure of the high atmosphere. Compt. Rend. 239, 1067-1069 (1954). (In French.)

Summary of various seasonal ionospheric phenomena at equatorial stations (including D-layer absorption, F2-ionization, F1·5-stratification and signal propagation) which indicate a remarkable amplitude of response, much greater than the seasonal variation of noon cos X (X = solar zenith angle). These are interpreted in terms of seasonal variations of the structure (temperature and its gradient, molecular dissociation, tides, winds and turbulence) of the high atmosphere at the same place. The "effective equator" follows the movement of the sun ±23°N and S of the geographical equator.
PA

DELOBEAU, F., R. Eyfrig, and . Rawer. Experimental results of ionospheric transmission of impulses at oblique incidence. Ann. Telecomm. 10, 55-64 (1955). (In French.)

Detailed account of the observational techniques used and results obtained on various radio links between Europe, W. Africa and U. S. A. Considerations are given to the ionospheric courses followed and the m.u.f.'s obtained. The latter are normally found to be greater than the values calculated by the classical methods.
EEA

DELOBEAU, F. Lunar tides in the ionospheric F2 layer above Dakar. Compt. Rend. 240, 222-224 (1955). (In French.)

Measured tides in f1F2 and h'F2 using data from 1 Jan. 1950 to 31 Dec. 1953. Finds feeble semi-diurnal and strong diurnal components in summer; says explanation difficult. Tabulates amplitudes and phases.
M

DELOBEAU, F., and K. Suchy. Ionospheric absorption at Dakar. J. Atmos. Terrest. Phys. 9, 45-50 (1956). (In French.)

For nonselective absorption found direct proportion between foD and sunspot activity. For selective absorption note increase of collision frequency at E peak; attribute to decrease of height. Give formulas for absorption and compare with those of Bibl, Busch, Rawer, and Suchy JATP0355 and with Bibl and Rawer JATP--51.
M

DELSEMME, A., and D. Delsemme. The night-sky red line at the equator. Ann. Geophys. 16, 507-524 (1960). (In French.)

The oxygen red line of the airglow was observed at Lwiro (2°S) for 465 hours during 148 nights between December 1957 and April 1959. The observed intensities were corrected for the contributions of the extraterrestrial light, the O H bands and the continuum. Contrarily to its behaviour in high latitudes, the red line often goes through a bright maximum (300 to 900 Rayleighs) around midnight. There exists a seasonal annual variation with a maximum near March and a minimum near September. Correlations with ionospheric data entirely confirm the nocturnal mechanism of the O_2^+ dissociative recombination in the F2 layer. They lead to an O_2 scale height of 38 km at an altitude of about 310 km, which agrees with recent atmospheric models. The surprising behaviour of the red line intensities at the equator can entirely be accounted for by the F2 layer behaviour. The nocturnal secondary maximum of ionization seems to belong to a whole geophysical phenomenon characteristic of the equatorial region.
PA

DENISOV, N. G. The absorption of radio waves in resonance regions of a non-homogeneous plasma. Radiotekhnikai Elektronika 4, 388-397 (March 1959). (In Russian; translation in Radio Engineering and Electronics.)

The absorption of electromagnetic waves propagating in a plasma in which the electron concentration is such that one of the refractive indices is infinite is investigated, both for the case when interaction between the ordinary and extraordinary waves is neglected and when it is taken into account. The results obtained are discussed with reference to wave propagation in the ionosphere.
PA

DESSLER, A. J. The propagation velocity of world-wide sudden commencements of magnetic storms. J. Geophys. Res. 63, 405-408 (June 1958).

The following model is presented for the propagation of a world-wide sudden commencement of a magnetic storm: A longitudinal hydromagnetic wave will be generated by the impact between a plasma cloud ejected from the sun and the earth's magnetic field. This wave will travel from the point of impact both east and west around the geomagnetic equator and carry the magnetic effect of the impact to the back side of the earth. It is shown that this hydromagnetic wave will be stable at an altitude of about 400 km and travel with a velocity of about 130 km/sec. Thus, it is proposed that sudden commencements do not occur simultaneously over the earth. Rather, about two minutes are required for a sudden commencement to be propagated around the world.
A

DICKINSON, A. H. Vertical radiation and tropical broadcasting. J. Brit. Inst. Radio Engrs. 16, 405-411 (1956).

It is suggested that broadcasting stations in the Tropics serving small densely populated areas should change to the medium-wave band. National stations should use short-wave vertical incidence 16-element binominal arrays; with 5 kW transmitters these would be capable of serving 90,000 square miles of territory, and frequency sharing is possible if co-channel stations are separated by 1500 miles. The stations require a total of 2 or

3 frequencies in the bands 2-1/2, 3-1/2, 5 and 9 Mc/s depending on location, but so far as possible the 3-1/2 and 5 Mc/s bands only should be used. Use of the minimum number of frequency changes assists listeners. EEA

DIEMINGER, W. Transient fine structure of the E-layer. J. Atmos. Terrest. Phys. 16, 179 (1959).

In rocket experiments a rather complicated fine structure of the E-layer was observed by several groups (AFCRC 1953, NRL 1954, "Skylark" 1958), and it was maintained that it did not show up on the ground-based ionograms taken simultaneously. It appears to me that that discrepancy is not a fundamental fault of ground-based echo sounders but lack of sensitivity of the specific types used for comparison.

At Lindau the fine structure of the E-layer is being observed on routine ionograms since the start of an improved ionosonde in 1950. For example a typical ionogram taken in 1952 (DIEMINGER, 1954) shows five stratification levels between E and F (Fig. 1). The ionosonde used at Lindau has a peak power of 10 kW and sweeps the frequency range of from 1 to 16 Mc/s within 8, 4 or 2 min. The pulse repetition frequency is 50 c/s, the pulse duration 80 μsec. The antenna system consists of three vertical rhombics used for transmission and reception simultaneously. The normal mode of operation is with 4 min sweeps since a loss of details is experienced as soon as the frequency variation is speeded up to 2 min sweeps. It can be shown that that loss is not due to the detuning effect but to the deterioration of the integrated signal-noise ratio. That ratio, however, becomes worse still for panoramic ionosondes with a total sweep duration of 15 sec or less. Since the selective absorption is very pronounced in the transition region between E and F it is not surprising that on panoramic ionograms a gap shows up where an equipment with high power and slow frequency variation gives a multitude of stratifications.

The variability of the fine structure of the E-layer may be demonstrated by Fig. 2. The records were taken with our standard ionosonde sweeping the subrange between 2.8 and 4 Mc/s only in quick succession (30 sec). The fine structure of the echoes between f_0E and f_{min} F2 is very complicated and varies from one record to the other. Apparently the variation of virtual height of the intermediate echoes is due to retardation which in turn varies considerably with the vertical gradient of electron density within the stratification. The multiple structure of the retarded F2-trace cannot be explained by vertical echoes alone. Doubtless off-vertical reflections are playing an important role.

The phenomena may be explained best by a region where the vertical gradient of electron density varies locally by small amounts, and which drifts over the point of observation. That picture implies of course horizontal gradients of electron density and tilts of the individual iso-ionic planes.

The records are taken at random, and are typical for normal conditions in winter-time. The degree of stratification, however, is subjected to large variations. A thorough investigation of the phenomena is in progress. Full details will be published in due course.
A

DIEMINGER, W., and G. Lange-Hesse. Some F layer phenomena at Tsumeb, South West Africa. IN: Some Ionospheric Results Obtained During the IGY, Proc. URSI AGI Committee, Brussels, Sept. 1959. 8-13 (Elsevier Publishing Co., New York, 1960).

The differences between the observed foF_2 values and those predicted at Tsumeb (South West Africa) were discussed. An improvement in foF_2 prediction was noticed after the observations of the International Geophysical Year have been taken under consideration. However, the effect of an ionospheric storm was much less in Tsumeb than in Lindau (West Germany). During the International Geophysical Year work a new anomaly of the foF_1 value was found in the daily variations at Tsumeb, because these variations did not quite follow the sun's zenithal angle. The variation showed, however, regularity during ionospheric storms. The observed results plotted in graphs, show the F_1 layer behavior during the sunspot maximum conditions when the difference between the F_1 and F_2 layer critical frequencies is very high.
MGA

DOMINICI, P., and F. Mariani. Some critical considerations on the parameters h' and f_o of the ionospheric layers. Suppl. Nuovo Cimento 4, 1589-1592 (1956).

It is well known that the physical interpretation of the behaviour of the F_2 layer is very difficult and that the questions connected with the singularities of this behaviour are very interesting for further progress of the ionospheric physics.

Our actual knowledge of the ionosphere is based almost only on the data obtained by standard methods in the various Observatories by vertical radio-soundings. The behaviour of the ionospheric layers is obtained from the

behaviour of the two parameters h' (minimum virtual height of reflection) and f_o (critical frequency of the ordinary ray).
Excerpt

DOUGHERTY, J. P. Some comments on dynamo theory. J. Geophys. Res. 68, 2383-2384 (1963).

We consider briefly the possibility that electrical linkage, through the exosphere, between magnetically conjugate points, may influence the dynamo currents. A very rough estimate suggests that the effect is worthy of quantitative study.
A

DSIR. Radio propagation through New Guinea rain forest. Rept. 8, DSIR Wellington, New Zealand; Australian Operational Research Section, Landforces Headquarters, Melbourne, Australia (1944).

The more important properties of ground aerials of any length have been investigated both theoretically and experimentally. This treatment, although detailed in the aspects that it covers, is by no means exhaustive. It deals mainly with the radiation properties of the aerials considered i.e. the relation between an aerial with specified physical constants and the wave it emits or picks up. The associated problem of the effects of an imperfectly conducting ground on an aerial lying on it is also very fascinating. By assuming values for the propagation constants of the aerials considered here, we do not need to consider this problem.

A few practical points arising in the use of ground aerials will now be considered. With aerials of length less than one quarter the wavelength of the wave in the ground aerial, the input impedance is capacitive. The aerial will, therefore, match easily to meet Army sets since they are usually designed to feed into a capacitive or purely resistive impedance. As the aerial length is further increased, the input impedance becomes alternatively inductive and capacitive at intervals of half a wavelength. The impedance finally (rapidly, if the attenuation in the aerial is at all large) settles down to a steady ohmic value, the characteristic impedance of the line. Thus, it is necessary, in very many cases, to convert the inductive input impedance of a ground aerial to a capacitive impedance in order to

resonate the aerial system. This is conveniently accomplished by shunting the aerial with a small condenser to the ground terminal of the set. The value of capacitance required is usually about .0003 μF, but may vary considerably from this figure.
A

DUBROVSKIY, V. G., and S. A. Kramarenko. Some patterns of the diurnal, seasonal, and latitudinal distribution of magnetic-ionospheric disturbances. Geomag. Aeron. 2, 614-622 (1962). (In Russian.)

Some characteristics of latitudinal, diurnal, and seasonal distributions of magnetic-ionospheric disturbances are examined. Hourly values of f_0F_2 deviations in 1952-1953 and 1957-1959 are used as initial data. Magnetic characteristics are taken from data of neighboring magnetic observatories.

It is found that the effect of a disturbed geomagnetic field is proportional to the geomagnetic latitude of the observation site. Geomagnetic latitudes 30°−40° are the boundary zone between mid-latitudinal and equatorial distribution of ionospheric disturbances. Two types of ionospheric disturbances are found: (1) magnetic-ionospheric disturbances that are characterized by a definite relationship to the level of geomagnetic activity and to the geomagnetic latitude of the observation site, by a decrease in Δf_0F_2 at all latitudes with a maximum inthe polar regions and a minimum at the equator, and by maximum disturbances during the equinox and minimum disturbances in winter; and (2) ionospheric disturbances during magnetically quiet days that are characterized by positive Δf_0F_2 values, increased disturbances at low latitudes and a maximum in winter at high and middle latitudes.

The presence of a definite positive correlation between magnetic-ionospheric disturbances and the level of geomagnetic activity testifies to the corpuscular nature of these kinds of ionospheric disturbances.

The assumption is made that the nature of ionospheric disturbances on magnetically quiet days is complex and must be associated with weak solar corpuscular radiation carrying low-energy particles, and with processes in the ionosphere itself.

A considerable number of papers is devoted to problems concerning the morphology of magnetic-ionospheric disturbances, and to the patterns of the geographical, seasonal, and diurnal distribution of ionospheric disturbances associated with geomagnetic field disturbances. But the importance of these problems for the forecasting of radio communication conditions and for the understanding of processes taking place in the upper

atmosphere, as well as some uncertainties and controversies in the conclusions of various authors require further study in order to generalize the extensive experimental material accumulated in recent years.

An attempt is made in the present paper to determine the characteristics of the latitudinal, diurnal, and seasonal distributions of magnetic-ionospheric disturbances on the basis of available ionospheric data and data on magnetic activity from ionospheric stations and magnetic observatories in the Soviet Union and India.

A

DUBROVSKIY, V. G., and S. A. Kramarenko, Some additional comments on the diurnal and geographical distribution of ionospheric and magnetic-ionospheric disturbance. Geomag. Aeron. 2, 299-301 (1963). (Original in Russian.)

The study of the diurnal, seasonal and latitude distributions of disturbance of the F2 layer of the ionosphere which we made earlier [1,2] has made it possible to draw conclusions relative to the existence of two categories of ionospheric disturbance, each of which has its special characteristics.

Thus, the disturbed state of the ionosphere observed at the time of magnetic storms is characterized by a sharp dependence on the level of geomagnetic activity and the geomagnetic latitude of the place of observation with a maximum at high latitudes, a decrease of the critical frequencies of the F2 layer at all latitudes and a clear seasonal dependence on the maximum frequency of occurrence of disturbed hours in equinoctial months. On the other hand, ionospheric disturbance is rather frequently observed when the magnetic field is quiet, and at such times is characterized by a more even geographical distribution, higher values of critical frequency and slight dependence on season of the year.

In order to determine the influence of geomagnetic activity on the diurnal distribution of disturbed hours in the F2 layer of the ionosphere, it was formerly customary to analyze the diurnal variation of the probability of occurrence of $+\Delta f_0F2$ and $-\Delta f_0F2$ exceeding 20% for days with magnetic indices 0.0, 1.0, 1.5 and 2.0 for a number of stations in the Soviet Union and India [1, 2]. It was found that the patterns of diurnal distribution of ionospheric disturbance on magnetically quiet and magnetically disturbed days differ considerably from one another.

We believe that the diurnal variation of ionospheric disturbance on magnetically disturbed days ($S_{D(d)}$) contains in implicit form the diurnal variations of ionospheric disturbance characteristic for a quiet magnetic field ($S_{D(q)}$) (the letters d and q in parentheses indicate a disturbed and quiet state of the geomagnetic field respectively). In this case, obviously, $\Delta S_D = S_{D(d)} - S_{D(q)}$ will represent the diurnal variation of magnetic-ionospheric disturbance, that is, that part of disturbance of the F2 layer

of the ionosphere that is fully related only to the disturbed state of the earth's magnetic field. $S_{D(q)}$ variations characterize the diurnal distribution of ionospheric disturbance in the case of a quiet magnetic field, that is, in the absence of an obvious corpuscular ionization agent.

Figure 1 a, b shows ΔS_D variations for the mean intensity of positive and negative values Δf_0 F2 and the probability of occurrence of $+\Delta f_0F2$ and $-\Delta f_0F2$ exceeding 20%, respectively, computed for the ionospheric stations Moscow (1), Ashkhabad (2), Ahmedabad (3) and Trivandrum (4) for the period 1957-1959. The corresponding $S_{D(q)}$ variations have been shown for comparison in Fig. 2, a and b.

Figure 3 shows ΔS_D variations of the probability of occurrence of disturbed hours in the F2 layer for Tixie (1), Leningrad (2), Moscow (3), Sverdlovsk (4), Irkutsk (5), Alma-Ata (6) and Ashkhabad (7) for years of minimum solar activity (1952-1953).

A study of the curves of $S_{D(q)}$ variations shows that the character of the diurnal distribution of ionospheric disturbance when the geomagnetic field is quiet does not reveal a sharp dependence on the sign of fluctuations of f_0F2 and the latitude of the point of observation. On the other hand, the curves of ΔS_D variations, that is, the diurnal distribution of magnetic-ionospheric disturbance associated with a disturbed state of the geomagnetic field, reveals a sharp dependence both on the sign of the disturbance and on the latitude of the point of observation. It is characteristic that ΔS_d variations of a negative magnetic-ionospheric disturbance, decreasing in amplitude with a transition to the equatorial regions, maintain positive values at all latitudes, whereas ΔS_D variations of a positive disturbance, having negative values in the middle latitudes, change sign at geomagnetic latitudes 30-40° with transition to equatorial regions. This effect is manifested most clearly in years of maximum solar activity. Thus, the most pronounced latitude dependence is manifested for a positive magnetic-ionospheric disturbance, which apparently is due to the well-known effect of change of the sign of magnetic-ionospheric disturbance with transition from the middle to equatorial latitudes.

An analysis of the $S_{D(q)}$ and ΔS_D variations also leads to the extremely important conclusion that the pattern of diurnal distribution of probability of occurrence of disturbed hours and the mean intensity of Δf_0F2 are virtually identical.

In our opinion, the proposed classification of ionospheric disturbance on the basis of its degree of relationship to the state of geomagnetic field for ionospheric and magnetic-ionospheric disturbances and the introduction of corresponding designations of their diurnal variations will help in further research related to clarification of the physical aspects of genesis and development of magnetic and ionospheric storms.

As is known [3, 4], the latitude distribution of critical frequencies f_0F2 is characterized by a symmetric variation of the electron concentration of the F2 layer relative to the geomagnetic equator and f_0F2 has a

minimum in the region of the magnetic equator. The maximum electron concentration occurs in the region of geomagnetic latitudes 14-18°. The f_0F2 values increase in the near-equatorial zone at the time of magnetic storms and this zone approximately coincides with the zone of the f_0F2 geomagnetic anomaly [5]. The latitude dependence of the probability of occurrence of ionospheric disturbances in the F2 layer as a function of the sign of anomalous deviations from the monthly sliding median for magnetically quiet (ΣK = 0 - 10, dashed line) and magnetically disturbed (ΣK = 35 - 45, solid line) days has been shown in Fig. 4, a and b in the form of a meridional profile drawn on the basis of ionospheric observation data for 1957-1959 for the stations Leningrad (1), Moscow (2), Irkutsk (3), Ashkhabad (4), Delhi (5), Ahmedabad (6), Bombay (7) and Trivandrum (8), situated between geomagnetic longitudes 120 and 150° E.

It is characteristic that both when the geomagnetic field is quiet and when there are geomagnetic disturbances in the near-equatorial region there is some increase in the probability of occurrence of disturbed hours in the F2 layer, with a maximum at the geomagnetic latitude of Ahmedabad – 13.6°N. This effect is manifested most clearly for negative disturbances and positive disturbances on magnetically quiet days.

The geomagnetic equator and the latitude of Askhabad (30.5°N) are characterized by a minimum probability of the occurrence of ionospheric disturbance. Thus, the secondary maximum in the frequency of occurrence of ionospheric disturbance coincides with the zone of the near-equatorial geomagnetic anomaly in the latitude distribution of f_0F2 and the minimum of ionospheric disturbance lies in the transition zone from the equatorial to the middle-latitude type of ionospheric disturbance. The latter indicates that the geomagnetic anomaly occurs not only in the distribution of critical frequencies of the F2 layer, but in the geographical distribution of ionospheric disturbance as well.
Excerpt

DUDZIAK, W. F., D. D. Kleinecke, and T. V. Kostigen. Graphic displays of geomagnetic geometry. RM 63-TMP-2, DASA 1372, Contract DA 49-146-XZ-109, GE TEMPO, Santa Barbara, Calif. (1 April 1963). AD-404 072.

This report contains sixty maps presenting computational data pertaining to the geometric properties of the geomagnetic field and a brief related theoretical description to make this material more meaningful. The maps display (1) the values of total field intensity (B) and McIlwain's magnetic shell parameter (L) for altitudes from zero to two thousand

kilometers, (2) the detailed value of total field intensity near the South Atlantic anomaly, (3) the traces in both hemispheres of points with a fixed value of B and L and (4) some other geomagnetic properties. The description includes tables of the geomagnetic coefficients used and a description of the codes utilized.
A

DUEÑO, B. Characteristics of a peculiar backscatter echo observed at a frequency of 21.6 mc. p.s. Res. Rept. 1, Contract AF49(638)172 Puerto Rico University, Rio Piedras (1958). AD-211 178.

Inspection of records of a backscatter experiment performed at the University of Puerto Rico at Mayagüez has revealed a very interesting echo which has never been observed at back-scatter stations located on higher latitude sites. This echo takes the form of a narrow thin line reflection extending in all directions with its slant range practically independent of its azimuthal bearing. The bottom edge of the line is believed to be due to a focussing effect of the minimal time delay type proposed by A. M. Peterson in 1951 while the upper edge is due to a focussing effect between the skip distance rays and rays at greater angles of incidence having the same time delays as the skip distance rays. At the frequency of operation, 21.6 mc, it is observed when the attenuation of the radio waves is at its highest. The range assumes values between 1000 and 2000 kilometers depending on time of the day and season. The lowest value of range, 1000 kms., occurs during the winter months. Since the thin line echo disappears during the summer months, when it is observed sporadically, the echo is assumed to be an F-2 layer echo. There are reasons to believe that, for a given parabolic distribution, with the greatest half thickness the thin line echo should produce the strongest focussing effect.
DDC

DUEÑO, B. Peculiarities and seasonal variations of transequatorial backscatter echoes as observed at Mayagüez, Puerto Rico, J. Geophys. Res. 65, 1691-1698 (1960).

As a result of a backscatter experiment on 21.6, 40.68, and 49.68 Mc/s, it has been observed that long-range transequatorial echoes, which are most prevalent during the equinoxial periods, also exhibit a minimum of transequatorial activity during the solstitial periods June, July and December, January.

The mechanism for the production of long-range transequatorial echoes (LRTE) is not well understood. Comparison of our data with National Bureau of Standards propagation predictions suggest that the echoes may result from the combined action of the evening equatorial bulge and sizeable concentrations in electron density at the north and south edges of the bulge. The large concentration of electron density in the north edge occurs over Bogotá and is easily observable in the late evening hours on the 40- and 50-Mc/s channels at slant ranges slightly under 4000 km.

From experimental evidence it is deduced that the angle of arrival of LRTE echoes is quite low and that the propagation mode is such that the wave stays a short fraction of its total path in the ionosphere. From the experimental data it is also anticipated that a 60-Mc/s backscatter radar would see LRTE activity for a very small fraction of time. At this point it is well to concede that backscatter results are on the pessimistic side if compared with ordinary one-way transmissions used in communication circuits.
A

DUEÑO, B. Measurement of ionospheric drift by radio-star observations. J. Geophys. Res. 66, 2355-2365 (1961).

Measurements of the fluctuations of the signals from the radio-star Cassiopeia have been made at Lajas, Puerto Rico. It has been found that there exists at this location a great increase in fluctuation activity during June and July which appears to be associated with the large-scale changes taking place in the F_S layer during the presunrise period. No significant relationship between fluctuation activity and E_s or between fluctuations and spread F was observed. Measurements of drift velocities by means of three spaced interferometers have also been made. It has been found that drift is toward SE in the evening hours and toward NW in the morning with transitions occurring at noon and at midnight. About 75 percent of all the drift measurements taken were easily analyzable by Putter's method. This is taken to mean that for 75 percent of the cases the random changes in the shape of the irregularities were either very small or were taking place very slowly in time compared with that taken by the irregularity to drift along the three interferometers.
A

DUEÑO, B. Interpretation of some sweep-frequency backscatter echoes. J. Geophys. Res. 68, 3603-3609 (1963).

We obtain a relation for the condition of minimum time delay focusing for a spherical earth geometry assuming an ionosphere with a parabolic distribution of ion density. Theoretical curves for the case of sweep-frequency backscatter (time delay versus frequency) are obtained that agree well with experimental values. Deductions from theory are made that explain characteristics of backscatter records obtained at Mayagüez (latitude 18, longitude 67.5). A frequency-independent constant time delay (22 msec) backscatter echo frequently observed in the south direction is explained with the help of an expression for the time delay used in deriving the minimum time delay condition.
A

DUFFUS, H. J., J. A. Shand, and C. S. Wright. Short-range spatial coherence of geomagnetic micropulsations. Canad. J. Phys. 40, 218-225 (1962).

An experiment designed to measure the coherence of natural geomagnetic signals at two stations 10 kilometers apart is described. A qualitative measurement was performed on a section of 1 c.p.s. signal (of unusual occurrence) and a quantitative measurement on a section of normal daytime record. The coherence tends to be high for moderate signal levels.
A

DULK, G. A. Faraday rotation near the transverse region of the ionosphere J. Geophys. Res. 68, 6391-6400 (15 December 1963).

It is shown that some of the equations used to describe Faraday rotation are often misinterpreted in the case of propagation through an anisotropic magnetic field when the cosine of the angle between the magnetic field and the wave normal changes sign along the ray path. Such a case is common when transmissions are from a high-altitude satellite in the region of the ionosphere in which the direction of propagation is nearly perpendicular to the earth's magnetic field. Use of the usual equations

can result in misinterpretation of the data. A set of modified equations is given, and these are shown to be consistent with measured Faraday rotation. Using the modified equations in a ray-tracing program, we analyze errors resulting from the use of several approximations near the transverse region. The approximations investigated are (1) quasi-longitudinal propagation, (2) straight line propagation, and (3) use of an effective ionospheric height.

DUNCAN, R. A. Lunar variations in the ionosphere. Austral. J. Phys. 9, 112-132 (1956).

Presents results of analysis of lunar variations of height and electron density of F2 layer for Canberra, Brisbane, and Washington. Finds height variation of 1 to 3 km with maximum at 06 lunar hours at moderate latitudes, and 09 lunar hours at geomagnetic equator. Critical frequency varies by 2 to 4%, is maximum at 09 and 04 lunar hours at moderate and equatorial geomagnetic latitudes. Assumes a Chapman current system at 100-km height causes lunar-geomagnetic variation. Calculates tidal winds needed to drive the current, the dynamo potential distribution, and hence the vertical drift of ionization in higher layers. Says divergence of drift velocity too small to explain lunar variations in foF2. Thinks amplitude of lunar tidal wind near E layer is about 45 times greater than at ground level.
M

DUNCAN, R. A. The behaviour of a Chapman layer in the night F2 region of the ionosphere, under the influence of gravity, diffusion, and attachment. Austral. J. Phys. 9, 436-439 (1958).

It is shown that, in the presence of diffusion, gravity, and attachment, a Chapman layer, no matter what its height, maintains its shape, decaying uniformly with an effective attachment coefficient equal to the true attachment coefficient at the height of the electron density maximum; and that, at the same time, the layer drifts bodily towards an equilibrium height.

It is then shown that a uniform vertical tidal drift will alter the equilibrium height of a Chapman layer.
A

DUNCAN, R. A. Computations of electron density distributions in the ionosphere making full allowance for the geomagnetic field. J. Geophys. Res. 63, 491-499 (1958).

Jackson's method of computing electron density distributions from h'f records has been modified slightly and adapted for use on an electronic computer. Reduction of a single h'f record takes about 20 seconds of computer time.

The method makes allowance for the geomagnetic field and is exact save for the uncertainty about the electron density between ionospheric layers which is inherent in the method of pulse sounding from the ground. Rocket measurements (Seddon, et al., 1954) enable a reasonable resolution of this uncertainty.

Some examples of electron density distribution at Brisbane are given. It is shown that the night-time distributions are much closer to the Chapman than the parabolic form. This is to be expected (Martyn, 1956) in a region in which the electron distribution is determined by the opposing processes of downward diffusion under gravity, and a height gradient of electron decay. The effect of geomagnetic disturbance on the day and night electron density profile is illustrated and discussed.

A

DUNCAN, R. A. The equatorial F-region of the ionosphere. J. Atmos. Terrest. Phys. 18, 89-100 (1960).

A comparison of data from ionospheric sounders at Chimbote and Panama, shows that afternoon critical frequencies in the equatorial zone are negatively correlated with those on the same meridian in the sub-tropical belts. This supports MARTYN's suggestion that ionization is transported from the equatorial zone to the sub-tropics.

The process suggested by MARTYN, electrodynamic lift at the equator followed by diffusion under gravity along the geomagnetic field lines to the sub-tropical belts, is investigated quantitatively, and it is shown that the process can account for the high sub-tropical electron densities observed.

It is shown that the diurnal variation of the correlation between Chimbote and Panama critical frequencies, the diurnal variation in the height, thickness and electron density of the equatorial F-region, and the diurnal variation of electron density enhancement in the sub-tropics, can all be ascribed to the simple diurnal electrodynamic tide expected from the observed magnetic variations, in conjunction with diffusion along the geomagnetic field lines.

A

DUNGEY, J. W. Convective diffusion in the equatorial F region. J. Atmos. Terrest. Phys. 9, 340-310 (1956).

This paper discusses the convective diffusion which Johnson and Hulburt showed could take place across the geomagnetic field in the F region near the equator. It is shown that the convective diffusion will increase any irregularities which may be present. The usual formula for the conductivity is found to be inappropriate when diffusion is involved. The convective motion is regarded as that of a gravity-driven dynamo and its speed is controlled by the current flowing along the lines of force into lower levels of the ionosphere. The speed is found to be inversely proportional to the east-west scale of the irregularities, and for a scale of 100 metres may be a few metres/sec.
PA

ECKERSLEY, T. L., and I. G. Millington. The limiting polarization of medium waves reflected from the ionosphere. Proc. Phys. Soc. 51, 110-128 (1939).

A method is described of measuring the polarization of a downcoming wireless wave which has been reflected obliquely from the ionosphere. Two rotatable crossed loops are adjusted to be in quadrature by dephasing one forwards and the other backwards 45° from resonance. With the usual goniometer technique the search coil gives zero pick-up when the tangent of the angle at which it is set is equal to the ratio of the axes of the projected polarization ellipse, and the frames are turned so that their planes are along the axes of this ellipse. Results obtained on medium-wave broadcasting stations are compared with ellipses calculated on the magnetoionic theory for an assumed angle of emergence and direction of the earth's magnetic field. The comparison shows that, within the present accuracy of the apparatus, the absorption due to electronic collisions does not appreciably affect the limiting polarization of the emergent wave, and sets an upper limit of 10^6 per sec. to the collisional frequency in the region where the polarization assumes its limiting value. The experiments also suggest that the ratio of the number of ions to the number of electrons in this region is not greater than 10,000, and further work with increased accuracy should give valuable information relevant to the inclusion of the Lorentz term in the magnetoionic theory for the E layer.
A

EGAN, R. D. Radar investigation of field-aligned irregularities located within the ionosphere at the magnetic equator. Paper presented to URSI Fall Meeting, San Diego, Calif., Oct. 1959.

No abstract available

EGAN, R. D. Anisotropic field-aligned ionization irregularities in the ionosphere near the magnetic equator. J. Geophys. Res. 65, 2343-2358 (1960). Similar material was submitted as a thesis to the Department of Electrical Engineering, Stanford University (Dec. 1959).

During the 1958-1959 International Geophysical Year, a three-frequency, swept-azimuth backscatter sounder was operated by Stanford University at Huancayo, Peru, in cooperation with the Instituto Geofísico de Huancayo. An unusual echo, which has been shown to be due to the presence of field-aligned ionization irregularities in the ionosphere, was discovered early in

the program. These equatorial scatter echoes (EqS) are observed on over 90 per cent of the days (at 18 and 30 Mc/s) and exhibit a diurnal variation very similar to that of the equatorial electrojet. By means of the back-scatter pulse observations, in conjunction with the Booker theory of back-scattering from anisotropic field-aligned irregularities, it has been possible to determine the size and extent of the scattering region. The E-region echoes originate at heights between 100 and 140 km. At times, however, the upper limit may extend to 200 km or more. F-region echoes have occasionally been observed which appear to originate at heights corresponding to the maximum ionization density of the layer. Observations of the strength of the EqS echoes indicate that the mean square fractional deviation of the electron density $(\Delta N/N)^2$ is between 10^{-2} and 10^{-5}. The discovery of the presence of equatorial field-aligned ionization irregularities has made it possible for the first time to describe adequately a number of equatorial ionospheric phenomena, including the mechanism of 'equatorial-type' sporadic E.

A

EGEDAL, J. On the lunar-diurnal variation in the earth-currents. Terrest. Mag. Atmos. Elec. 42, 179-181 (1937).

In examining earth-potentials at Jersey Marc Dechevrens twenty years ago found variations of tidal type, and in examining ordinary earth-current observations the author demonstrated a lunar influence on the earth-current potential-gradient at Ebro, Spain, for the hours 10 to 11 a.m. In the following a complete determination of the lunar-diurnal variation of the earth-current potential-gradient will be mentioned and discussed.

A

EGEDAL, J. The magnetic diurnal variation of the horizontal force near the magnetic equator. Terrest. Mag. Atmos. Elec. 52, 449-451 (1947).

In a communication to the Edinburgh Meeting of the Association of Terrestrial Magnetism and Electricity, Dr. A. G. McNish has given the results from an analysis of the diurnal variations of the magnetic elements for five observatories in the Western Hemisphere. In this analysis also the diurnal variations at Huancayo are used. McNish points out that the establishment of the observatory at Huancayo "has led to the discovery of magnetic diurnal variations markedly different from those expected for such a region." In using these new data from Huancayo the analysis of McNish has become of great value. McNish makes it clear, that older analysis of

magnetic diurnal variations are not able to represent the diurnal variations at Huancayo, and that "more terms would have been needed to fit completely the horizontal components".
A

EGEDAL, J. Daily variation of the horizontal magnetic force at the magnetic equator. Nature 161, 443-449 (1948).

In a communication on the daily magnetic variation to the Edinburgh meeting, 1936, of the Association of Terrestrial Magnetism and Electricity, A. G. McNish states that the establishment of the magnetic observatory at Huancayo has led to the discovery of a daily variation of the horizontal force (H) "markedly different from those expected for such a region", the amplitude being more than twice the value found from the analysis of S. Chapman.

McNish has based his investigation on the assumption that the daily variation depends on magnetic co-ordinates, and points out that the daily variation of the declination varies considerably in a very narrow region at mag. lat. 0. The great daily variation of H at Huancayo is explained as an augmentation of the normal varying field originating from special circumstances. For Huancayo this augmentation, which is increasing when the distance of the magnetic equator from the geographic equator is increasing, is great.

The present note gives the results from an examination based on the assumption that the daily variation depends on the distance of the place of observation from the magnetic equator (magnetic inclination = 0). The examination is made for H using the total range of the daily variation for all days (September) corresponding to mean sunspot number. The data are given in the table, namely, names of observatories, geographic co-ordinates, magnetic inclination and the total range of H.

Total Range of Daily Variation of H

Station	ϕ	χ	Mag. inclination	Total range
Alibag	18·6° N.	72.9° E.	24·4°	38·5
Antipolo	14·6 N.	121·2 E.	16·2	45·5
Madras	13·1 N.	80·2 E.	7·6	49·5
Kodaikanal	10·2 N.	77·5 E.	4·3	82·5
Batavia	6·2 S.	106·8 E.	-31·6	52·3
Huancayo	12·0 S.	284·7 E.	2·3	125·0

In the accompanying diagram the variation of the total range of H with the magnetic inclination is given. The application of geomagnetic co-ordinates has been avoided in this case, for the magnetic field at the place—and not the magnetic field of the earth as a whole—is the deciding factor.

In accordance with the assumption, the curve has been drawn symmetrically to the line corresponding to the magnetic equator. The curve suggests the range is great only for a strip of land about 300 km. to both sides of the magnetic equator. This augmentation at the magnetic equator of the normal daily variation of H may therefore arise from a varying electric current flowing in a very narrow zone above the magnetic equator at a height of the same order as the E layer. The values of the total range of Huancayo and Kodiakanal are in agreement with the above explanation of the augmentation of the amplitude of the daily variation of H, but this is not the case as regards the values for Madras and Antipolo, for which observatories there seems to be no addition to the normal daily variation.

It should be added that E. V. Appleton in a recent communication has shown the existence of a marked minimum in the F_2 layer critical frequency at mag. lat. 0. Possibly a connexion exists between this phenomenon and the augmentation of the variation of H at the magnetic equator.

However, more observations of the daily variation of H from stations near the magnetic equator are needed before a complete representation of the variation with the magnetic inclination can be given. Further, it may be desirable to examine the special electric conditions in the atmosphere over the magnetic equator by means of radio investigations.

EGEDAL, J. Report of committee to promote observations of daily variation of the horizontal magnetic force between and near the geographic and magnetic equators, 1948-1951. Terrest. Mag. Elec. Bull. 10, 286, 61 (1951).

The Committee was appointed at the Oslo Assembly in 1948. Its members are: Banerji, Berlage, Coulomb, Egedal (Chairman), Giesecke, Herrinck, Lutzow-Holm, Madwar, Martyn, McNish and Romañá.

The task of the Committee is in the first line to organize observations of the range of the daily variation of the horizontal force for different longitudes at stations about 150 km apart lying in a N-S line crossing the magnetic and geographic equators with at least three stations lying outside the area between the two equators, as well to the north as to the south. A further extension of the task of the Committee might be the establishment of provisional or permanent observatories in places suitable to the purpose where not only magnetic but also ionospheric measurements, should be made. As to the establishment of permanent observatories, a collaboration with the "Committee on selection of sites of new observatories for terrestrial magnetism and electricity" would be necessary. The Committee has only taken up the arrangement of observations. In most cases members of the Committee have been active (Togoland, South America, Gulf of Guinea and India). The observations have ordinarily been made by means of QHM's

belonging to the Association. Through Circular Letters the members have been informed of the work of the Committee. Two of these Circular Letters have, in accordance with the wish of the Editor, been published in the Journal of Terrestrial Magnetism and Atmospheric Electricity, and Journal of Geophysical Research (vol. 53, 470-476 (1948); vol. 55, 98-100 (1950)).
Excerpt

ELLING, W. Reflecting properties of the ionosphere between 350 and 1500 kc/s at Tsumeb. IN: Some Ionospheric Results Obtained During the IGY, Proc. Symposium URSI/AGI Committee, Brussels, Sept. 1959, 252-259 (Elsevier Publishing Co., New York, 1960).

Three types of ionographs have been obtained at Tsumeb: the sporadic E type with no retardation at the low frequency end of the F echoes; the intermediate layer type between E and F at a height of 150-230 km and assumed to be thick because of distinct retardation for the immediate and F echoes; the normal E layer with distinct retardation of the low frequency end of the F echoes corresponding to the critical frequency of the normal E layer. The night time decrease of the critical frequency of the E and the intermediate layer were plotted as function of time after sunset. Several diagrams present the frequency occurrence of echoes originating from different layers for different frequencies. The reflection loss in db on 830 Kc as a function of reflection height was investigated and plotted in graphs.
MGA

ELLIS, G. R. Measurement of the gyro-frequency in the F region. J Atmos. Terrest. Phys. 11, 54-58 (1957).

This paper describes a method of measuring the F-region gyro-frequency from P'f records, using the relation $fH = f_x - f_z$. The observed values of the critical frequencies must be corrected for errors arising from lateral deviation and horizontal gradients of critical frequency.

It is shown that the lateral deviations of the O, X, and Z modes, calculated with an approximate value of f_H, and the observed values of f_x, f_o, and f_z, provide sufficient information to obtain both the horizontal gradient of critical frequency and the gyro-frequency. The results of an

analysis of P'f records obtained at Hobart, Tasmania, are given. It was found that at a mean true height of 378 km, the mean gyro-frequency was 1·53 Mc/s, compared with an extrapolated value, using ground parameters, of 1·40 Mc/s.
A

ELLYETT, C. D. Echoes at D-heights with special reference to the Pacific Islands. J. Geophys. Res. 52, 1-14 (1947).

Describes 1,302 observations of echo at equivalent height 50 km observed at Pitcairn Island. Reflection usually between 2.5 and 5.0 Mc/s, was seen 65% of time during day, had summer and winter minimum of activity, and approximately 1/3 strength of E-region echo. Describes similar echoes observed at Raoul Island and Christmas Island. Considers them D-region echoes possibly characteristic of tropical region.
M

ESTRABAUD, S. Effects of the solar eclipse of Feb. 25, 1952, on the ionospheric F2 region in equatorial Africa. Compt. Rend. 235, 1521-1523 (1952). (In French.)

The detailed history of the development of the eclipse as regards its effects on the F-layer is traced. The eclipse shows considerable analogies with that observed at Huancayo on Jan. 25, 1944, and supports the hypothesis that the F_2 region consists of 2 layers, designated X and G. These are normally amalgamated as a single thick layer, but in eclipse the upper (G) component ("old F2" layer) is little affected, whereas the X component ("new F2" layer) suffers a decrease of ionization and appears as a new layer in the F1 region. It is suggested that the G component may be due to coronal or corpuscular radiation.
PA

ESTRABAUD, S. Influence of the solar eclipse of February 25, 1952, on the ionospheric E region in equatorial Africa. Compt. Rend. 236, 833-835 (1953). (In French.)

Results of ionospheric soundings made at Bangui (4°22'N, 18°36'E). While the critical frequency of the E2 region decreased markedly at the onset

of the eclipse, the precise time at which the effects of the eclipse commenced in the E1 layer is certainly between 5 and 20 min before first contact. This may be interpreted by postulating the existence of two active regions on the sun. The relation between the solar zenith angle (χ) and electron density (N) may be written $N^{1.6}\cos^{-1}\chi$ = const. and three different interpretations of this are considered.
PA

EVANS, J. V., and G. N. Taylor. The electron content of the ionosphere in winter. Proc. Roy. Soc. A 263, 189-211 (1961).

Observations at two closely spaced frequencies of the Faraday rotation of moon-reflected radio waves are described. These measurements have provided accurate values for the total electron content of the ionosphere for many hours on successive days. The observations reported here span a period of one month during the winter of 1960. Short-period fluctuations of the total electron content were observed. These were of about 2 to 3% in amplitude and occurred chiefly during the day-time. The gross shape of the F_2 region as determined by the ratio of the number of electrons above the F_2 peak to the number below was roughly constant during the day, but showed a wide scatter of values at night. The scale height of the ionizable constituent at the F_2 peak was found to be about the same as that of the neutral particles during the day, indicating almost complete mixing. At night, the scale height of the ionizable constituent appeared to increase with the planetary magnetic index Kp. It is not possible to say if this was the result of heating of the region or the consequence of electro-dynamic drifts.
A

EVANS, J. V. Radar methods of studying the earth's ionosphere. IN: Physics of the Solar System, Part I. Proc. Conference on Physics of the Solar System and Reentry Dynamics, 31 July to 11 Aug. 1962, Virginia Polytechnic Institute, Blacksburg, Va., 166-209.

Recent studies of the ionosphere are reviewed to compare their results to present theories of the F region. The methods used in these studies include radar reflections from the moon and radar incoherent scatter. While these methods have not furnished a wealth of results comparable with those of ionosondes, the studies support the theory for the F_2 region advanced by Yonezawa. It is shown that a small modification of the theory proposed by the Cambridge group will yield a hypothesis which is capable of

accounting for (a) the diurnal variation of the F_2 region, (b) the geomagnetic anomaly, and (c) the temperature latitude winter anomaly.
STAR

EYFRIG, R. The problem of the diurnal variation of the electron density of the F_2 layer at equatorial stations. Naturwissenschaften 37, 67-68 (1950). (In German.)

The equinoctial diurnal variations in F_2 layer critical frequencies for 3 equatorial stations (Huancayo, Bandoeng and Palau) are briefly considered. It is suggested that the flattening of the diurnal curves over the mid-day periods (observed at Huancayo and Palau) may be ascribed to geomagnetic influences and furthermore that the characteristic summer diurnal variations for higher latitude stations may also be attributed to such causes.
PA

EYFRIG, R. Lunar effect on the median height of the ionospheric F_2 layer. Compt. Rend. 235, 736-737 (1952). (In French.)

Brief note on diurnal and seasonal variation in the height of the (M 3000) F_2 factor at Huancayo, Peru and Freiburg, Germany. An analysis of values of the factor obtained at the two places indicates that marked 12-hour periodicity (with an amplitude of $\pm 3\%$) showing maxima at lunar noon and midnight exists at Huancayo from Nov. to Feb., while no similar lunar effect could be found at Freiburg. More conclusive results can be expected from more accurate measurements which are being conducted now at the latter place.
MGA

EYFRIG, R. Contribution to the study of the effect of geomagnetism on the F1 layer. Compt. Rend. 241, 759-761 (1955). (In French.)

Results for various stations show that on the magnetic equator f_0F1 is a minimum (as reported by Ghosh, 1955), $h'F_1$ is a minimum, and the factors M3000-F1 and F1-3000-MUF have maximum values.
PA

EYFRIG, R., E. Harnischmacher, and K. Rawer. The worldwide characteristics of the height of the F_2 layer. Geofis. Pura Appl. 33, 153-162 (1956). (In German.)

On the worldwide behavior of the height of the F2 layer. Plot maps of MUF factor M (3,000) (a parameter varying inversely with altitude of F_2

layer) for latitudes from magnetic equator to Ottawa, all in Americas. Find daily minimum on magnetic equator; sunrise maximum and daily maximum at geographic latitude of about 40° N. As solar activity increases M values generally decrease.
M

EYFRIG, R. A critical discussion about special ionospheric characteristics. J. Atmos. Terrest. Phys. 11, 163-176 (1957).

Uses examples showing that measurements of MUF (3,000) F2 are unambiguously related to change of solar activity only for limited regions of earth. States M (3,000) values presently reported at different stations are too contradictory to justify worldwide examination. Finds strictly linear relations at well-established stations of Washington, Slough, Huancayo, Brisbane, Christchurch, and Johannesburg. Stresses that exact height statements are urgently needed.
M

EYFRIG, R. The geographical distribution of ionization and the equator of the F_2 layer. J. Geophys. Res. 67, 1678-1682 (1962).

Results obtained from ionospheric stations at low latitude during World War II enabled Appleton [1946] to formulate the hypothesis of a minimum of ionization existing in the vicinity of the geomagnetic equator. A more detailed description has been given by Maeda, Uyeda, and Shinkawa [1946], by Bailey [1948], and since that time by many others. The test made by all of them was to plot the observed data as a function of geomagnetic latitude. Later it was found that the magnetic dip angle gives better agreement [Eyfrig, Harnischmacher, and Rawer, 1950].

The lack of stations in the oceanic regions of the world made it difficult to test Appleton's discovery all over the globe and to determine an 'ionospheric equator.' Only during the IGY were enough stations established in the vicinity of the magnetic equator, so that now we have more exact information on the behavior of the F_1 layer.
Excerpt

EYFRIG, R. W. The effect of the magnetic declination on the F_2 layer. J. Geophys. Res. 68, 2529-2530 (1963).

Appleton [1946], Bailey [1948], and other workers proved that the critical frequency of the F_2 layer (f_0F_2) and other characteristics of this layer are controlled by the magnetic field of the earth. They demonstrated that results compiled all over the globe are clearly dependent on the magnetic latitude or on the magnetic dip. Repeating their tests with the results of the past twenty years we have found some anomalies, which are known

in the literature as the 'Siberian effect' or the east-west coastal anomaly in the United States and elsewhere. In this region for a given magnetic dip there is a great dispersion of the noon and midnight values of f_0F_2, particularly in local summer.

We have found that the daily variation of f_0F_2 is typically different and varies with the magnetic declination of the station [Eyfrig, 1962] Figure 1 shows a typical example of the influence of magnetic declination on two stations in the western hemisphere. The two stations, St. John's and Victoria, have practically the same latitude, magnetic dip, and value of cos I/F (I = inclination, F = total field), but a different declination: 29° W and 25° E, respectively. The diurnal variation is quite different, St. John's (declination west) exhibiting an enhancement of f_0F_2 in the evening and night hours whereas Victoria (east) has a 'winterlike' behavior with a maximum near noon. A similar difference in the diurnal variation is found all over the northern hemisphere. The noon values of f_0F_2 can be largely different too. Figure 2 shows results for stations in Europe and Asia.

We have further found that the amplitude of diurnal variation of f_0F_2 ($f_0F_{2\,max}/f_0F_{2\,min}$) is controlled during summer months by the magnetic declination; see, for example, stations listed in Table 1. Figure 3 gives evidence that this effect is much smaller for stations of western than for stations of eastern declination.

Testing stations of the southern hemisphere in the same manner, we have found that the depression of the noon values occurs here in the region of eastern declination. This means that a reversal of our effect takes place near the geographic or geomagnetic equator. Table 2 gives a survey of the controlling influence of the magnetic declination all over the globe.

Considering that the magnetic declination has a secular variation, our effect gives a slow but permanent alteration of the diurnal variation of f_0F_2 at a fixed station, even when solar activity and magnetic character are equal. We may speak of a secular variation of f_0F_2.

The influence of the magnetic declination upon the diurnal variation of f_0F2 is so strong that a theory taking no account of the magnetic declination as a parameter of control will fail to describe the features of the F_2 layer. We believe that a complete theory should include dynamical features. For the description of ionization we propose a general formula including latitude magnetic inclination and declination.

A complete paper describing tests in detail will be published in Annales de géophysique.

Excerpt

FARLEY, D. T., Jr. A theory of electrostatic fields in a horizontally stratified ionosphere subject to a vertical magnetic field. J. Geophys. Res. 64, 1225-1233 (Sept. 1959).

A theory is developed to describe quantitatively the idea that in an ionized gas subject to an imposed magnetic field, such as the ionosphere, the lines of magnetic flux are approximately equipotential lines. The ionosphere is assumed to be horizontally stratified, and the case in which the earth's magnetic field is vertical is considered. Small-scale electrostatic fields are studied with a view towards elucidating the phenomena of spread F and radio star scintillation.

The analysis indicates that in the ionosphere the results are strongly affected by the variation of conductivity with height, as well as by the anisotropy. For a reasonable model of the ionosphere it is shown that it is possible, under certain conditions, for a horizontal field three kilometers or larger in extent, at a height of about 120 or more kilometers, to produce a similar, localized electric field in the F region, not appreciably reduced in strength. The height of the source is the most important factor, but the temperature and ionization-density profiles are also significant. The fact that the strength of the small-scale fields in the F region could vary by one or two powers of 10 for plausible diurnal variations of the ionospheric parameters suggests that these fields could perhaps be responsible for the puzzling diurnal behavior of spread F and radio star scintillation.
A

FARLEY, D. T., Jr. A theory of electrostatic fields in the ionosphere at nonpolar geomagnetic latitudes. J. Geophys. Res. 65, 869-877 (1960).

The theoretical electrostatic coupling between the dynamo region and the F region of the ionosphere is examined at non-polar geomagnetic latitudes. It is found that, under certain conditions, significant coupling between these two regions can occur at all latitudes, even for electrostatic fields with horizontal scale sizes as small as a few kilometers. The coupling is strongest at the poles and weakest at the equator. Strong coupling will also occur between magnetically conjugate portions of the F region, while weaker but significant coupling will exist between conjugate portions of the dynamo region.

The strength of the electric source field which would be produced by an irregular, horizontally stratified wind in the dynamo region is then computed, both for polar and for nonpolar latitudes. The results indicate that, to a large extent, the polarization charge that the local winds attempt to build up leaks away vertically and forms closed current loops. In other words, the 'internal impedance' of the thin source layer is greater than the 'load impedance' presented by the rest of the ionosphere.

Finally, the possibility that electrostatic fields may cause significant electron-density variations in the F region is examined briefly. It is concluded that they will not.
A

FARLEY, D. T., Jr. A plasma instability resulting in field-aligned irregularities in the ionosphere. J. Geophys. Res. 68, 6083-6097 (1963).

A theory of the two-stream ion wave instability in a plasma is developed that takes into account both the effect of collisions of the ions and electrons with neutral particles and the presence of a uniform magnetic field. Applying the results to the ionosphere, we find that irregularities of ionization density should arise spontaneously in regions in which a sufficiently strong current is flowing normal to the magnetic field lines. These irregularities will be strongly aligned with the magnetic field and may have a wide range of wavelengths. The various predictions of the theory are in agreement with the observed characteristics of certain field-aligned irregularities found in the equatorial ionosphere that are associated with the equatorial electrojet. Similar irregularities often appear in the polar ionosphere during auroral displays; it seems very likely that these are caused by the auroral electrojet.
A

FARLEY, D. T., Jr. Two-stream plasma instability as a source of irregularities in the ionosphere. Phys. Rev. Letters 10, 279-282 (1963).

The purpose of this note is to describe an extension of the theory of the two-stream plasma ion wave instability and an application of the theory to the physics of the ionosphere. We shall include in the theory the effect of a magnetic field and also the effect of collisions with neutral particles. Both of these effects can be important in the ionosphere. We find that the qualitative and quantitative predictions of the theory are in agreement with the observed characteristics of a certain type of irregularity found in the equatorial ionosphere. These are often referred to as "equatorial sporadic-E" irregularities. Similar irregularities often appear in the polar ionosphere during auroral displays; it seems very likely that these too are caused by the two-stream instability.
A

FEJER, J. A. Semidiurnal currents and electron drifts in the ionosphere. J. Atmos. Terrest. Phys. 4, 184-203 (1953).

The differential equations of the dynamo theory for the terrestrial ionosphere are solved numerically under simplifying assumptions.

The calculated current densities are used to estimate tidal velocities in the ionosphere necessary to produce the quiet day magnetic variations. A tidal amplification of about 60 compared with velocities on the ground is calculated.

The calculated velocities and phases of vertical electron drifts are in reasonable agreement with experimental determinations of lunar tidal variations in measured virtual height of the different ionospheric layers.

The calculated velocities and phases of horizontal electron drifts fit observations on long duration meteor echoes but the calculated phases are opposed to those obtained from fading measurements. The fading measurements appear therefore to refer to air movements and not to electron drifts.

A

FEJER, J. A. The interaction of pulsed radio waves in the ionosphere. J. Atmos. Terrest. Phys. 7, 322-332 (1955).

Preliminary daytime measurements of radio-wave interaction in the lower ionosphere with pulse transmitters are described. Interpretation of the results with the aid of the theory of Bailey and Martyn (1934a, 1934b, 1935) yields the collision frequency, the electron density, and the energy-loss coefficient G.

The resulting collision frequencies are in substantial agreement with results based on laboratory measurements by Crompton, Huxley, and Sutton (1953), and with a value obtained from the observation of partial reflections by Gardner and Pawsey (1953). The electron densities are near the values of Gardner and Pawsey. The value obtained for G is very much higher than those resulting from laboratory measurements (Crompton, Huxley, and Sutton, 1953). The latter apply, however, to high excess electron energies, while the excess electron energy during the present measurements was low.

The results of the observations described in this paper appear to lend support to the original form of the theory of Bailey and Martyn and not to its alternative development recently suggested by Huxley (1953).

A

FEJER, J. A. Theory of auroral electrojets. J. Geophys. Res. 68, 2147-2157 (1963).

Two mechanisms are described for the formation of electrojet currents in the auroral zone. Both mechanisms require the existence of

magnetospheric convection in which only particles of relatively low energy participate. It is essential to both mechanisms that particles of one sign (positively or negatively charged) should predominate among the energetic ones that do not participate in the convection of the magnetosphere. In the first mechanism the convection of the magnetosphere is taken to be of tidal origin, driven by the electric polarization fields associated with the dynamo current systems. In the second mechanism the convection is assumed to be the corotation of the magnetosphere with the earth, as modified by the solar wind that distorts the geomagnetic field. In both mechanisms the ionospheric currents are a consequence of the relative motion between the less energetic particles that almost fully participate in magnetospheric convection and the more energetic particles whose adiabatic drift motion across the magnetic field is only slightly perturbed by the electric fields associated with the convection of the magnetosphere. If the particles that do not participate are assumed to be the trapped energetic protons observed by Explorer 12 during magnetically quiet days, either mechanism predicts variations of the order of $\pm 50\gamma$ in the horizontal component of the geomagnetic field at auroral latitudes.
A

FEJER, J. A. Theories of the ionospheric F region. A review. IN: Landmark, B., ed., Advances in Upper Atmosphere Research. NATO Advanced Study Institute, Corfu, July 1960, AGARD. 209-226 (Macmillan Co., New York, 1963).

Observations of the F layer have provided the ionospheric physicist with many surprising results. A summary of these very complex results, first for magnetically quiet and then for disturbed periods, has been given in one of the present series of lectures. A common aspect of the puzzling features, often called anomalies, of the F layer is that they cannot be explained by the characteristics of the ionizing radiation only. In this respect the F layer and particularly its upper part, the F2 layer appears to differ from the E layer which responds rather closely in a manner predicted by simple theory to the changes in ionizing radiation, caused for example by changes of the solar zenith angle or of the sun spot number.

One of the main reasons for this peculiar behaviour of the F layer is believed to be the very much lower rate of decay of ionization in it. In the E region this decay time is less than an hour while in the F2 region decay takes many hours.

The first and most obvious consequence of this slower decay is a considerable time lag between the diurnal variation of the ionizing radiation and the ionization density. The second and even more important consequence is the possibility of a redistribution of the ionization by movements before it disappears by one of the many possible loss processes. In view

of the nature of the stratification vertical movements are particularly (though not exclusively) important in this respect.

Movements of ionization in the F region can have at least three different causes. The first of these is diffusion which tries to establish a hydrostatic equilibrium in the ionized component of the earth's atmosphere in the presence of the earth's gravitational field. In view of the existence of the ionized layers such an equilibrium is never present below the height of maximum ionization and diffusion tries to bring it about.

The second possible cause of movements of ionization is the existence of electric fields acting in combination with the earth's magnetic field.

Finally the third possible cause is the existence of a wind (a motion of the neutral particles) within the F region. Movement of ionization is caused by the component parallel to the geomagnetic field of such a wind.

A satisfactory theory of the F layer would therefore require a knowledge of the rates of all ionization and loss processes in addition to a knowledge of the electric fields and winds. Our knowledge of these quantities is at best incomplete and therefore existing theories are still of a very tentative nature. Great advances have been made however and it is the purpose of this lecture to describe them.

It is convenient to start with the magnetically undisturbed F region. Considerable progress has been made recently in the determination of the rates of ionization and loss processes using improved methods of deriving the electron density profile from ionosonde records (Ratcliffe et al., 1956). Our understanding of the nature of the so-called dynamo current system and particularly our knowledge of the electric fields associated with this current system have also increased. The great importance of drifts caused by these electric fields in the F region was first pointed out by Martyn (1948). A quantitative analysis of the effect of these drifts on the undisturbed F layer has been carried out by Japanese workers.

The methods used by these workers have been extended to the explanation of ionospheric storms in terms of the S_D current system although there is at present no agreement on the causes of this current system itself.
Excerpt

FERRARO, V. C. A. Magneto-hydrodynamics. Nature 176, 234-237 (6 Aug. 1955).

The paper is an account of a discussion at the Royal Society on May 5, 1955. It dealt with motion of a conducting fluid in a magnetic field, e.g. currents in the ionosphere and solar atmosphere. The aurora and equatorial

electrojet are other examples. The discussion also covered toroidal fields, generation of magneto-hydrodynamic waves in rare ionized gases, hydromagnetic turbulence (with exchange of energy between velocity field and magnetic field), etc. Calculation of the acceleration of cosmic-ray particles by the galactic magnetic field gave an acceleration time of 10^6 yrs, comparable with the mean life of the energetic particles.
MGA

FERRARO, V. C. A., J. E. C. Gliddon, and P. C. Kendall. Effects of diffusion of electrons near the magnetic equator. Nature 188, 1017-1018 (1960).

The authors discuss the latitude variation of electron density in a model F2 layer which takes account of production, loss and vertical diffusion of ionization. Their curves show a flat maximum at the magnetic equator, contrary to the conclusion of Schmerling (1960) that vertical diffusion could give rise to a minimum of electron density at the equator; reasons for this discrepancy are discussed. They conclude that the equatorial anomaly of F2 layer electron density is caused by processes not included in their model, such as horizontal diffusion.
PA

FERRELL, O. P. Enhanced trans-equatorial propagation following geomagnetic storms. Nature 167, 811-812 (1951).

Report on successful radio amateur communication in Oct.-Nov., 1949, on frequency of 50 Mc/s between N. and S. America, during, or shortly after, moderately severe, or severe geomagnetic storms, indicating enhanced F2-layer ionization in equatorial regions at such times.
PA

FERRELL, O. P. Very-high-frequency propagation in the equatorial region. Paper presented before URSI Spring Meeting, Washington, D.C., 16-18 April 1951.

Radio amateur observations in the frequency range 50.0-54.0 mc are being collected throughout the Western Hemisphere. Sky-wave propagation in the geographic tropical zone may be divided into three categories, which are: (1) sporadic-E reflections; (2) F_2-layer reflections, particularly associated with ionospheric storms in the temperate latitudes; (3) post-sunset F_2-region scatter. The effect of these modes upon vhf propagation are

summarized with particular emphasis placed upon the hitherto unreported post-sunset scatter. The results of the present study indicate that the scattering is observed over fairly long paths, but is restricted to those months around the equinoxes.
Proc. IRE

FINNEY, J. W., and E. K. Smith. Report on the IGY oblique-incidence sporadic-E and F-scatter program. NBS Tech. Note 48, National Bureau of Standards, Boulder, Colo. (March 1960).

The IGY Oblique-Incidence Sporadic-E Measurements program was instigated to test the longitude effect in temperate zone sporadic E. To accomplish this two CW 50 Mc circuits, both approximately 800 miles in length, were installed, one between the Philippines and Okinawa in the Far East, and the other between Panama and Cuba in the Caribbean. In addition to sporadic E a very peculiar evening signal was observed during the equinoxes on the far eastern circuit which we have referred to as the "evening signal anomaly" or the "Far Eastern Anomaly". Sporadic E, as expected, was three to five times more frequent in the Far East than in the Caribbean, the factor depending upon what transmission loss level is taken. The evening signal anomaly appears to be of F-region origin and is at least 100 times more frequent over the Far Eastern circuit.
J. NBS

FINNEY, J. W., E. K. Smith, and L. H. Tveten. Report on further investigations into F-region scatter in the Far East. NBS Tech. Rept. 6768, National Bureau of Standards, Boulder, Colo. (1961)

No abstract available.

FLEMING, J. A. Summary of the year's work, Department of Terrestrial Magnetism, Carnegie Institution of Washington. Terrest. Atmos. Elec. Mag. 38, 323-330 (1933).

The study of extensive observational material in hand continues. The diurnal variation of declination at Huancayo, on the magnetic equator, varies considerably, even on very quiet days, and at Watheroo on quiet days

the horizontal intensity has, on the average, a small diurnal variation. Results indicate that the system of assigning a numerical magnetic character to each day is not altogether satisfactory for the world-wide investigation of activity. In the study of ionisation, the character of the diurnal variation of large ions if dound to change with the season of the year, and there is a reciprocal relationship with the manner of variation of small ions. Reflections from the E- and F-layers of the upper atmosphere have been observed, and the virtual heights of the layers determined. The splitting of the echo from the F-layers on the higher frequency is due probably to magnetic double refraction. The disintegration of lithium- and boron-nuclei by high-speed protons has been investigated. An extensive programme in terrestrial electricity is being carried out at the International Polar Year Station, College-Fairbanks, in Alaska. The study of secular changes in the earth's magnetic elements was continued by means of expeditions, and by co-operative work with other organisations.
PA

FLEMING, J. A. Summary of the year's work, Department of Terrestrial Magnetism, Carnegie Institution of Washington. Terrest. Atmos. Elec. Mag. 42, 399-406 (1937).

A magnetic effect of the diurnal-variation type has been associated with a definite region of the ionosphere. The simultaneity of fade-out, magnetic and earth-current effects with solar outbursts in the region of sunspot areas has been confirmed by direct observation at Huancayo. It was also shown that a magnetic storm can produce world-wide changes in cosmic-ray intensity. At Huancayo the lunar influence on variations of the earth's magnetism is so great that it may be noted in a single day's record. The Department began, in March, 1937, to issue weekly bulletins on the state of the earth's magnetic field in the U. S. A. which are useful as supplying advance estimates of radio-transmission conditions. Data relating to atmospheric electricity are being compiled which may assist in forming conclusions as to the source of the current which charges the earth, and as to the manner in which the earth acquires and maintains a negative charge on the surface where fair weather prevails. It is found that water vapour combines with large ions which then become more efficient in removing the small ions in the atmosphere. Data show a high correlation between size of the large ion and absolute humidity. Work on radioactive material in the atmosphere indicates that a large part of the radioactivity produced in the lower atmosphere is positively charged. There is a probability that the presence of nuclei reduces the atmospheric conductivity, their effectiveness increasing with the altitude. A light radio-transmitter with Geiger counter was constructed which, when carried up in a sounding balloon, sent out a signal when a cosmic-ray corpuscle passed through the counter. At intervals it also sent signals which indicated the altitude of the balloon. Further

attention has been given to the variation of the diurnal range in earth-currents during the sunspot cycle, and to the lunar diurnal variation in earth-currents. In the ionosphere, the increase of ionisation of all regions with the advance of the sunspot cycle was pronounced. Measurements show that reflection of radio waves from the E-region is primarily due to electrons. An automatic multifrequency ionospheric recorder has been completed which records the virtual height of waves of given frequency range, and rapid ionospheric changes can be followed in detail. In nuclear physics further measurements have been made on the "new" physical force which binds protons and neutrons, and the construction of an atomic physics laboratory was begun in May, 1937. The section of land magnetic survey continues its activity in different parts of the globe. Work at the observatories and oceanographic reductions are also reported.
PA

FLEMING, J. A. Summary of the year's work, Department of Terrestrial Magnetism, Carnegie Institution of Washington. Terrest. Atmos. Elec. Mag. 43, 409-416 (1938).

The year ended June 30, 1938, saw the completion of the Atomic Physics Observatory and progress in the installation of its electrical equipment. The generator and tube are designed to operate at potentials of over 5 million volts. Automatic multifrequency equipments for ionospheric measurements have been installed at Huancayo and Watheroo. Tests were made on blue mud taken from the N. Atlantic, in which changes in magnetic declination as great as 90° were measured. The material is regarded as representing sediments deposited over several thousand years. A world map of secular variation activity was constructed for the interval 1885-1922, showing isopors for the total change vector. The weekly magnetic character figures (C_A) for 7 American-operated observatories were compiled and published weekly. The Potsdam Kennziffer differs from C_A in the division of the Greenwich day into 8 3-hour intervals. The average characteristics of disturbance in the earth's magnetic field are in good agreement with the world-wide atmospheric-electric current system of magnetic storms proposed by Chapman. If these currents flow in closed circuits in the atmosphere, their height is deduced as roughly 100-150 km. World-wide decreases of 3 to 5% in daily means of cosmic-ray intensity were associated with changes in the earth's magnetic field during two major magnetic storms. Measurements of air conductivity, and the effect of Aitken nuclei at a height of 19-22 km. in reducing this are discussed. The lunar variation in earth currents is semi-diurnal in character and is about 1/6th that of the solar diurnal variation. Isolation of the radio fade-out in a particular region brought the result that ionisation in the outer atmosphere, produced by u.v. rays emanating from bright chromospheric eruptions, is absorbed almost exclusively below the level of 90 km. It is

argued from this that the electrical currents causing the diurnal variation in the earth's magnetism must flow below this level. The ionosphere is now under continuous observation at Huancayo and Watheroo. The Department's pioneer measurements of new nuclear forces have been amply confirmed.
PA

FLOOD, W. A., Jr. <u>The fading of ionospheric signals.</u> Tech. Report 17, Signal Corps Project 182B, Contract DA 36-039-sc-56748, Cornell University (15 Aug. 1954). (Ph.D. dissertation.)

The characteristics of short-term fading on quiet ionospheric days are the following: at vertical incidence, scatter is decisive better than 50 percent of the time; at oblique incidence, scatter is important less than 40 percent of the time. These observations are consistent with Herlofson's theory of plasma resonance. A rough calculation indicates that resonant blobs are 10^6 times more effective than the non-resonant blobs of Booker-Gordon formula. The dependence of the amount of scatter upon the angle of incidence which is apparent in the experimental results has been investigated with an approximate analysis and it is shown that the critical angle beyond which scatter is less and less important is given by

$$\theta_o = \sqrt{\frac{L}{H}}$$

L = blob size diameter
H = scale height of layer

This is an interesting result in that the critical angle is proportional to the size of the blobs. It offers a possible explanation for the observation that when WWV 5 megacycles exhibits a peculiar flutter fade, the ratio of the mean to the variance of the amplitude distribution of signals recorded under these conditions is very likely to be greater than the same ratio of signals recorded during normal periods. The distortion of the signal received under these flutter conditions is thought to be due to the lack of phase correlation of the two sidebands rather than amplitude fading. It is suggested that the absence of distortion during quiet periods is due to the fact that there is a good deal of phase correlation between the sidebands and the carrier.

A theory of the spread-F echoes on the ionospheric sounder has been proposed. The theory uses E-region blobs and the Booker-Gordon formula to show how the spread in critical frequency and virtual height can be explained when one considers the effects of propagation at angles of incidence other than normal. Such a theory could explain the presence of F-spread

on nights when there are no indications of the presence of aurora. The blob sizes necessary are entirely within the realm of sizes generally envisaged for the E-region.
Excerpt

Note: Introduction has excellent history of fading studies.

FLOOD, W. A. A study of spread F. Final Rept., Contract AF 19(604)-5460, Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y. (Oct. 1960).

Experiments were carried out to examine the feasibility of the lobe swept interferometer technique, a method for determining the cone angle of arrival of spread-F echoes. Angle-of-arrival data for one night are presented. Amplitude distributions and power spectra of echoes obtained during severe spread-F conditions on another night are also analyzed.
A

FOOKS, G. F., and I. L. Jones. Correlation analysis of the fading of radio waves reflected vertically from the ionosphere. J. Atmos. Terrest. Phys. 20, 229-242 (1961).

The correlation analysis of Briggs et al. (1950) and Phillips and Spencer (1955) has been applied to the fading of radio waves reflected from the E- and F-regions of the ionosphere, observed at three closely spaced receivers.

Histograms are presented showing the size of the characteristic ellipse of the radio diffraction pattern formed on the ground, and also the axial ratio and the direction of the major axis of this ellipse. Results are presented which show the importance of random changes in the pattern relative to pure drift in producing fading. Corresponding results from other parts of the world are reviewed briefly. Drift velocities found by correlation analysis are compared with those found by the simple time-delay method, and it is shown that the errors in the time-delay method are considerable.

A comparison is made between the method of calculation used by Briggs et al. and the six-point method of Yerg (1955); the former is to be preferred.
A

FOOKS, G. F. The fading of radio waves reflected vertically from the ionosphere during magnetic storms. J. Atmos. Terrest. Phys. 22, 43-49 (1961).

Some features of the reflection of radio waves from the ionosphere at vertical incidence during magnetic storms are described, and it is shown how correlation analysis can be applied to the fading at such times. The analysis shows that the irregularities in the diffraction pattern on the ground are smaller and more nearly aligned with the earth's magnetic field than they are for quiet conditions. Drift is a much more important source of fading than random changes in the pattern. The drift velocity is large, and is usually directed toward the West.
PA

FORBUSH, S. E. Variations in strength of wind system, in the dynamo mechanism for the magnetic diurnal variation, deduced from solar-flare effects at Huancayo, Peru. J. Geophys. Res. 61, 93-105 (1950).

Hourly means of solar-flare effects, or crochets, in magnetic horizontal intensity (H) at Huancayo exhibit, during daylight, a diurnal variation like that in H. This variation is expected, since McNish showed (see 1 of "References" at end of paper) that flares produce magnetic effects indistinguishable from those which would result from an increase in strength of the current system responsible for the normal magnetic diurnal variation, S_q. On the other hand, it is found that the average crochet size in H is greater by a statistically significant amount for groups of days with greater S_q amplitude. For example, the average crochet size is 80 per cent larger for a group of 49 days with average $\delta W_2 = 25.2$ (Bartels' measure of amplitude of S_q) than for a group of 48 days with average $\delta W_2 = 1.6$. Although δW_2 increases with sunspot number, the crochet size does not. Thus, the larger average size of crochets, at Huancayo, on days when S_q is larger, indicates that the strength of the wind system is, on the average, greater on days with larger S_q. From the change in crochet size, the strength of the wind system must vary by 50 per cent at least.
A

FORBUSH, S. E., and E. H. Vestine. Daytime enhancement of size of sudden commencements and initial phase of magnetic storms at Huancayo. J. Geophys. Res. 60, 299-316 (1955).

Applying statistical tests to 428 SC's, the frequency of occurrence is

found to be independent of time of day. Statistical tests indicate that the average sizes of SC's and of IP are both significantly greater during the daylight hours at Huancayo. Also from 102 SC's occurring between 08^h and 14^h 75° WMT at Huancayo, we find that the average size of SC's is greater for those days with the larger diurnal variation (S_q) in H. This result is not only statistically significant but also the average size of SC's was about 50 per cent greater for the group of days with 50 per cent greater diurnal variation in H. The diurnal variation of SC's averaged on 75°, WMT for San Juan and Honolulu is practically negligible. The augmentation of SC sizes at Huancayo with S_q in H at Huancayo was found to be the same whether the average size of the same SC's at San Juan and Honolulu was large or small. No significant diurnal variation was found in the frequency of occurrence of SC's observed both at Huancayo and Watheroo. A simple explanation is offered for the diurnal variation in the frequency of SC's found by Newton from Greenwich results.

The relation of daytime enhancement of the size of SC's to S_q in H at Huancayo indicates that the current system responsible is closely associated with the electrojet effect responsible for the large diurnal variation in H at Huancayo. The effects found are not predicted on the basis of the Chapman-Ferraro theory of magnetic storms in its present form. One possibility being examined is that the electric currents in th atmosphere near Huancayo are driven by electrojets of polar regions.
A

FORBUSH, S. E., and M. Casaverde. Equatorial electrojet in Peru. Publication 620, Department of Terrestrial Magnetism, Carnegie Institution of Washington (1961).

Magnetograms with H, D, and Z traces were obtained on the west coast of South America between the geographic equator and latitude 22°S at 15 temporary survey stations, at 4 IGY observatories, and at Huancayo. Analysis of these and other data shows that the primary S_q electrojet near midday is a band, about 660 km wide, of eastward current at about 100-km height centered over the dip equator, near which it accounts for about half the total range of S_q in H. The induced field of the S_q jet is compatible with that of its negative image at 600-km depth and consistent with results from an analysis of a bay disturbance in the auroral zone. No jet effects are found at night, and there is no evidence for seasonal changes in the location of the jet. The center of the jet follows the secular change in the geographic latitude of the dip equator. There is no evidence for jet effects in D_{ST}. Jet effects are found near midday for sudden commencements for solar flare effects (crochets), and for sudden changes, probably associated with S_D disturbances. For the average of solar flare effects near midday the ratio of the jet effect near the dip equator to the "normal" for the jet effect is about twice the corresponding ratio for the average S_q jet. For

sudden commencements at night the vertical field changes sign at geographic latitude 8°S, which corresponds to the location of Simpson's cosmic-ray equator at the same longitude; the change in sign of ΔZ for these sudden commencements occur within a narrow range of latitude, indicating that the current system responsible for sudden commencements probably flows in the upper atmosphere.
MGA

FREDRIKSEN, A., and R. B. Dyce. Ionospheric absorption investigations at Hawaii and Johnston Island. J. Geophys. Res. 65, 1177-1181 (1960).

Measurements of ionospheric absorption by the cosmic-noise monitoring method show that, at certain tropical latitudes, an irregular component of absorption is often present in the evening hours. If the variable absorption is present at one observing site (Johnston Island), then variations are also likely to be present at another station about 1325 km away (Hawaii). The individual variations of absorption as a function of time are not correlated at the two stations, however, suggesting that the scale of the patches causing the absorption must be less than about 1000 km.

An attempt is made to find a correspondence between hourly averages of the apparent absorption with other ionospheric parameters. Both a nighttime and daytime absorption are observed. A greater nighttime component appears at Johnston Island than at Hawaii, implying the existence of a latitude dependence. Correlation with spread F or with sporadic E on the basis of ionosonde data from Maui was not found, although a correlation is apparent between cosmic-noise absorption and ionosonde minimum reflection frequency during geomagnetically quiet periods. There is good correlation between average hourly values of the absorption and F, critical frequency f_0F_2. This latter observation is explainable by the shielding effect of the F region.
A

GARRIOTT, O. K. The determination of ionospheric electron content and distribution from satellite observations. Part 1. Theory of the analysis. J. Geophys. Res. 65, 1139-1157 (1960).

Two techniques are described which permit the integral of the electron density up to the satellite height to be deduced from the satellite radio transmissions. One method is based on the rate of polarization rotation due to the Faraday effect. The other method depends on a measurement of the total angle of polarization rotation at the time of closest approach of the satellite. If useful results are to be obtained, a number of corrections to assumptions made in the simplified analysis are necessary to account for path splitting between the two magneto-ionic components, error in the 'high-frequency approximation,' refraction, and satellite-antenna motion. Owing to the slow rotation of the satellite perigee position, the height of the passage at any given latitude varies. Variations of the integrated electron density with height can then be related to the electron-density profile. The results of the observations of Sputnik III radio signals in an 8-month period are included in part 2.
A

GATES, D. M. Preliminary results of the National Bureau of Standards radio and ionospheric observations during the International Geophysical Year. J. Res. NBS 63D, 1-14 (1959).

A review is given of the activities of the National Bureau of Standards during the International Geophysical Year. The equipment used on each project is described and preliminary results of the observations are given. The following areas of research are discussed: (1) World Warning Agency, (2) Ionospheric Vertical Sounding Stations, (3) VHF Propagation, (4) VHF Equatorial Forward Scatter, (5) Radio Noise Network, (6) Radio Satellite Observations, (7) Airglow Observations, and (8) World Data Center for Airglow and Ionosphere.
A

GATES, D. M. NBS radio, ionosphere, and airglow observations during IGY. Trans. Am. Geophys. Union 40, 391-401 (1959).

Ionospheric vertical sounding observation, including soundings from equatorial close-spaced chain of stations in South America, electron density profiles along 75 W meridian, and vertical incidence soundings from Antarctica; VHF equatorial forward scatter experiments; radio noise

Antarctica; VHF equatorial forward scatter experiments; radio noise network, radio satellite observations, and airglow observations.
EI

GAUTIER, T. N., R. W. Knecht, and A. G. McNish. Lunar stratification of the F2-layer at Huancayo, Peru. International Council of Scientific Unions, Proc. Mixed Commission on Ionosphere, Brussels, Sept. 1950, 100-105 (1951).

Careful statistical analysis of time of separation of the F2 layer into two strata or layers, shows a strong dependence on the lunar hour and phase, but only during daylight (based on Huancayo, Peru data for Oct. 1948–Feb. 1949). Similar evidence of lunar stratification was found in the Christmas Island and Leyte, P.I. records (1945–1946). This supports the theory of Mitra and of Bailey and Menzel (1947) regarding drift of ions down along lines of magnetic force from high levels near the geomagnetic equator.
MGA

GERARD, V. B. The propagation of world-wide sudden commencements of magnetic storms. J. Geophys. Res. 64, 593-596 (1959).

A study of the times of three sudden commencements, recorded on August 3, September 21, and November 6, 1957, respectively, at ten widely-separated magnetic observatories, indicates that when main and preliminary impulses are both recorded at one place (as in the typical SC*) they really begin approximately simultaneously. Therefore, it would appear that in nontropical regions the rate of growth of the so-called preliminary impulse is usually greater than that of the main impulse, so that the latter is obscured until the former begins to decay.

Differences around the earth between recorded times of the first impulse, whether the sudden commencement is an SC or SC* type, are only a few seconds, and the evidence suggests that the position of the sun controls the hemisphere in which the sudden commencement first occurs. This finding is interpreted in terms of the Singer shock-wave theory to mean that, as would be expected, the shock wave enters the auroral zone nearest the sun first and produces the sudden commencement a few seconds earlier

in that hemisphere. At the equinox the sudden commencement times are roughly symmetrically distributed with respect to the geomagnetic equator.
A

GETTEMY, J. W. Magnetic daily variation at Koror. J. Geophys. Res. 67, 1885-1888 (1962).

Method of exhibiting magnetic daily variations using contours based on running means can give more precise indication of seasonal changes in daily variation than conventional methods; this method is applied to variations at Koror, which are of particular interest owing to Koror's location almost exactly on magnetic dip equator; contour charts give new evidence that ionospheric current shifts with seasons and that throughout International Geophysical Year period equatorial electrojet was located to north of Koror.
EI

GHERZI, E. Ionosphere and weather. Showers at Macao during the southwestern monsoon. Notas Científicas, Nos. 3 and 4, Serviço Meteorológico, Macao (1952).

In contrast to a number of bad forecasts made in 1949-51 by Far East weather services, the author maintains that his method (first used in 1939) of predicting weather from the height of the ionospheric layer which reflects pulses (6 Mc) would have given correct forecasts every time. If the reflecting layer is at 230-280 km then Siberian (polar continental) air is expected for 12 hours, and if it is an F layer at $>$ 300 km, then a tropical air mass is expected. If a typhoon is about 400 km from Macao it will not reach station if echo is from 230-280 km, but will from 300 km region.
N

GHOSH, M. Global characteristics of the separation between the F_1 and F_2 layers of the ionosphere. Indian J. Phys. 27, 421-430 (1953).

Records of a number of ionospheric stations in north and south latitudes have been analysed to study the global characteristics of the seasonal and solar cycle variations of the separation between the F_1 and F_2 layers of the ionosphere. So far as the seasonal variation characteristics are concerned, they are found to be similar to those observed by Appleton for the height variation of the F_2-region. The variation of the separation with the sunspot activity shows the following unexpected features: At high latitude stations the separation follows the trend of sunspot activity in local summer. In local winter, however, in such latitudes, there is no association between the two. At stations close to the geomagnetic equator, the separation is related to sunspot activity in an inverse manner in all the seasons. At stations of low intermediate latitudes, no appreciable correlation exists between variation of sunspot activity and the variation characteristics of the F_1-F_2 separation in any season. (The separations all refer to the mean noon values.) The seasonal and latitudinal variations can be explained (if the effect of tidal forces are taken into account) on the basis of the current hypothesis of the composite F-region formation, namely, that the F_1 and F_2 regions belong to a common bank of ionization and two maxima are produced in this common bank due to the peculiar physical characteristics of the atmosphere in this region. Regarding the variation characteristics of the separation with sunspot activity no simple explanation is possible with the present state of knowledge.
PA

GHOSH, M. Determination of the F-region collisional frequency over Calcutta. J. Atmos. Terrest. Phys. 8, 116-118 (1956).

The diurnal variation of the collisional frequency of the F region, calculated from the absorption of a radio wave passing through it, varies from 102/sec at midnight to 5 X 10^3/sec near noon. The rate of rise increases with cos X, which is explained by a rapid rise of temperature in the F region with the approach of noon.
N

GHOSH, S. P. Early morning variation of ionization and the true height of region F of the ionosphere. Indian J. Phys. 14, 101-107 (1940).

Results of observations carried out at Calcutta (22° 33' N) for a period of 1 year (1937-38) on the early morning variation of F-ionization are

described. It is found that the average F-ionization, which decreases during the earlier part of the night, begins to increase after attaining a minimum. The hour at which the increase begins varies with the season. It occurs earliest in mid-winter and shifts towards the early morning hour with the approach of summer. In mid-summer there is no pre-sunrise increase of ionization. This is explained as due to cooling of the layer as a whole. Further, it is found that the early morning minimum occurs after sunrise at region F in all seasons. In order to find out the hour of sunrise at region F, its true height has been calculated from the observed (P' — f) curves. Generally, the true height has been found to be about 80 km. less than the observed equivalent height. Curves depicting the variation of the hour of sunrise with height, taking into account the effect of atmospheric refraction, have been drawn.
PA

GIPPS, G. de V., D. I. Gipps, and H. R. Venton. Note on night-time phenomena in the F2-region at Brisbane. J. Coun. Sci. Indus. Res. (Australia) 21, 215-221 (1948).

(h', f) records made on the multifrequency ionospheric recorder at Indooroopilly reveal certain departures from normal F_2 region formation at night. These phenomena are classified in three groups and possible ionosphere configurations to produce these phenomena are discussed.
A

GISH, O. H., and W. J. Rooney. On earth-current observations at Watheroo magnetic observatory, 1924-1927. Terrest. Mag. Atmos. Elec. 35, 79-90 (1930).

The earth-current measuring system at Watheroo Magnetic Observatory provides for a number of independent records of both components of potential gradient, a feature which has proven helpful in detecting and locating the source of disturbing effects. The results obtained during the four-year period, 1924-1927, are discussed. The diurnal-variation curve of the northward component has a mean range of 1.14 millivolts per kilometer with maxima at $17^h.5$ and $12^h.5$ and minima at 8^h and $17^h.5$ (120th

east meridian mean time). The records resemble those obtained in the northern hemisphere at Berlin and Ebro except that the curve is inverted and smaller in amplitude. The reversal in the direction of current-flow points to a symmetrical distribution of earth-currents with reference to the equator. The small amplitudes can be explained on the basis of the unusually high conductivity of the region about Watheroo. No regular change was observed in the mean diurnal-variation for individual years. The range of the diurnal-variation curve varies with season from 0.71 millivolts per kilometer in June (midwinter) to 2.06 millivolts per kilometer in October (late spring), and the morning minimum and midday maximum shift forward with increasing height of Sun. The amplitudes of the three principal harmonics vary with season in a similar manner, indicating a single predominating cause for seasonal variation in the normal activity. The eastward component is extremely small at Watheroo; its diurnal-variation curve has, in general, a double period and a mean range of less than 0.15 millivolt per kilometer.
A

GISH, O. H., and W. J. Rooney. Results of earth-current observations at Huancayo magnetic observatory, 1927-1929. Terrest. Mag. Atmos. Elec. 35, 213-224 (1930).

The apparatus and equipment used and the natural features concerned with the measurement of earth-current gradients at the Observatory maintained by the Carnegie Institution of Washington near Huancayo, Peru, are described. A dual system of electrodes is installed and the potential differences are registered by a recording potentiometer. Although the region embraced by the measuring system is fairly flat yet evidence is found which indicates that the general northwesterly direction of watercourse and mountain ridges here doubtless influences the direction of the electric currents.

The character of the diurnal variation, as derived from records for all complete days, is exhibited by means of charts and tables and the Fourier coefficients of the diurnal variation are given for the three-year means, for the means of individual years, and for the three-year means grouped by months. The mean diurnal-range of the northward component is 2.83 mv per km. The maximum occurs at 9^h, the minimum at 15^h (75° west meridian mean time) and the amplitudes during the hours of darkness are relatively small. The same description applies to the component at right-angles to this (values being considered positive for currents flowing eastward) except that the mean range (3.26 mv per km) is somewhat greater. The direction of the current is northwestward from $2^h.5$ to $12^h.5$ and southeastward the remainder of the 24-hour period. The times of the daily maximum and minimum are constant throughout the year, which is contrary to the findings at Berlin, Ebro, and Watheroo. However, in

gei. ral agreement with the results at these other places, the mean diurnal-range changes with season, the principal minima (northward 1.89 mv per km, eastward 2.18 mv per km) occurring in J'une and maxima (northward 3.50 mv per km, eastward 4.00 mv per km) in March and October.

Disturbances (variations of relatively short and irregular period with amplitudes considerably greater, in the average, than those of the diurnal variation) predominate during the daylight hours.

A

GLIDDON, J. E., and P. C. Kendall. Theoretical world curves of maximum ion density in a quiet F-region. J. Atmos. Terrest. Phys. 18, 48-60 (1960).

The global variation of electron density in the F2-region is investigated on the assumption of uniform temperature, uniform attachment-type law of recombination, a diffusion coefficient varying inversely as the density of neutral particles and a Chapman ionization law. Electron density is calculated as a function of altitude and of local time at a number of different latitudes for the equinox and solstices. World curves of maximum ion density are deduced and compared with Millington's curves. The curves presented here are "drawn out" in the east-west direction as appears to be the case with the corresponding curves obtained by ionosonde methods. Although the latter are plotted against the geomagnetic latitudes, this broad similarity seems to indicate that diffusion plays a significant part in the control of F2-ionization.

A

GLIDDON, J. E., and P. C. Kendall. Theoretical world curves of maximum F2 ionization--II. J. Atmos. Terrest. Phys. 20, 183-188 (1961).

Values of N_mF2 have been computed from an analytical solution of the equation governing diffusion of ions in the F2-region. The mathematical model takes account of electron production, attachment-like recombination and a rate of diffusion which depends upon the ambient air density and also on the geomagnetic latitude. Results are plotted on a grid of geomagnetic latitude and local time and are compared with curves drawn from world-wide ionosonde records.

A

GLIDDON, J. E., and P. C. Kendall. A mathematical model of the F2-region. Appendix--horizontal diffusion into an eclipsed equatorial F2-region. J. Atmos. Terrest. Phys. 24, 1073-1099 (1962).

The previously obtained periodic solution of the equation governing vertical diffusion of ionization in the F2-region is generalized to include a uniform upward or downward drift velocity. The electron density, expressed in the form of a definite integral, is a function of the three parameters representing attachment-type recombination, diffusion and drift velocity respectively. The solution is used to discuss (1) electron distributions under middle latitude conditions, (2) the latitude dependence of electron density assuming the ionization to be constrained by the geomagnetic field lines and (3) the behaviour of the F2-region during solar eclipses.
IAA

GLOVER, F. N. A survey of spread F. NBS Tech. Note 82, National Bureau of Standards, Boulder, Colo., 1-67 (1960).

Examples of spread-F forms occurring at different latitudes are presented, illustrating the classification of spread into range type and frequency type. The occurrence patterns of spread-F at different latitudes are correlated with other geophysical phenomena. Magnetic latitude and time within the sunspot cycle appreciably affect the pattern of spread occurrence. Instrumental techniques and their advantages for spread studies are outlined. The principal theoretical explanations of spread-F are summarized. A single mechanism need not be postulated as responsible for all types of spread occurrence or at all latitudes.
A

GLOVER, F. N. Recent magnetic observations in the Philippines. J. Geophys. Res. 68, 2385-2394 (1963).

Two magnetic variometers have been continuously operated at comparable longitudes at Baguio and Cebu, Philippines, 900 and 300 km north of the magnetic equator, respectively. An attempt has been made to separate the electrojet contributions to the monthly mean of the daily range in H and Z. The jet appears to change its form with the season. The overhead disturbance currents appear north of Cebu at night, but south of Cebu during the day. Micropulsations, of peak-to-peak amplitude of 1γ or greater, have a nonzero occurrence probability at any hour, with a

maximum at local noon and a secondary maximum about midnight. The Johnston Island July 9, 1962, disturbance effects on the Philippine magnetic traces are presented.
A

GNANALINGAM, S., and K. Weekes. D-region echoes observed with a radio wave of frequency 1.4 Mc/s. IN: The Physics of the Ionosphere, 63-70 (The Physical Society, London, 1955).

By means of an experimental method of unusual sensitivity (Gnanalingam 1954) a search has been made for weak echoes from the ionosphere using radio frequencies near 1.4 Mc/s. Echoes could be observed if the reflection coefficient was greater than 3×10^{-5} (attenuation less than 10 nepers). It was found that on several occasions during the winter months echoes could be detected during the daytime from heights in the D region between 75 and 90 km. Sometimes these echoes were detectable at the same time as echoes from the E region (from heights of about 110 km) but at other times the E-region echoes were absent. On the occasions when D-region echoes were observed, the absorption of waves of 2 Mc/s reflected from the E region was abnormally high and this abnormal absorption was greater when the D-region echoes were observed alone. It is the purpose of this paper to discuss the significance of these observations.
A

GOLDBERG, R. A. The effect of diffusion on the equilibrium electron density distribution in the F region near the magnetic equator. Scientific Rept. 184, Pennsylvania State University, University Park, Pa. (1 May 1962).

On the basis that electrons are constrained to move along the lines-of-force of the earth's magnetic field, and that the primary forces acting are due to gravity and pressure gradients, a two-dimensional partial differential equation is derived for the equilibrium electron-density distribution around the magnetic equator in an isothermal F region. A solution is developed in the form of a power series in magnetic latitude. By using a Chapman-like profile at the equator as a boundary condition, it is shown that the solution exhibits the major features of the well-known geomagnetic

anomaly as observed at the equinoxes. The solution also predicts the electron density distribution above the F_2 electron peak, where there are presently no observations as a function of magnetic latitude. The effect of varying sunspot number is examined.
STAR

GOLDBERG, R. A., and E. R. Schmerling. The distribution of electrons near the magnetic equator. J. Geophys. Res. 67, 3813-3815 (1962).

It is shown that simple arguments based on the diffusion of electrons can explain qualitatively the more striking effects seen in the electron distribution near the magnetic equator. The assumption of constant electron density along a field line, though apparently giving a fairly good description of the variation of electron density with dip angle below the F_2 peak, is not soundly based and leads to difficulties above the F_2 peak. Examination of the limiting case of diffusive equilibrium indicates the direction in which an electron distribution is perturbed by diffusion and gives results above the F_2 peak that do not conflict with the meager information available.
A

GOLDBERG, R. A., P. C. Kendall, and E. R. Schmerling. Geomagnetic control of the electron density in the F region of the ionosphere. J. Geophys. Res. 68, 417-427 (1963).

The solution of a problem recently treated by Goldberg and Schmerling is written in a simple closed form. The problem concerns a possible explanation of the geomagnetic anomaly in terms of diffusion along the magnetic lines of force for a special model of the F_2 layer at the magnetic equator. At great height the results obtained are roughly in agreement with observations made by the Alouette (S-27) satellite on October 3, 1962. The theoretical electron density at fixed height is given as a function of magnetic latitude for a wide range of expected conditions at various phases of the solar cycle. Curves showing the latitude variations of $[\partial(\log N)/\partial r]^{-1}$ at great height are also given. The results are discussed.
A

GOLDBERG, R. A., and E. R. Schmerling. The effect of diffusion on the equilibrium electron density distribution in the F region near the magnetic equator. J. Geophys. Res. 68, 1927-1936 (1963).

On the basis of the assumptions that electrons are constrained to move along the lines of force of the earth's magnetic field, and that the primary forces acting are due to gravity and pressure gradients, a two-dimensional partial differential equation is derived for the equilibrium electron density

distribution around the magnetic equator in an isothermal F region. A solution is developed in the form of a power series in magnetic latitude. By using a Chapman profile at the equator as a boundary condition it is shown that the solution exhibits the major features of the well-known geomagnetic anomaly as observed at the equinoxes. The solution also predicts the electron density distribution above the F_2 electron peak, where there are presently no observations as a function of magnetic latitude. It is also suggested that there are additional perturbations, not included in this theory, which give rise to the asymmetries observed at other seasons, but these are not responsible for the main effects.
A

GOLDMAN, S. C., and S. Horowitz. Synchrotron radiation decay at equatorial sites. J. Geophys. Res. 68, 4865 (1963).

Riometer measurements in Africa show that following the creation of the artificial electron belt by the nuclear explosion of 9 July 1962, 30 Mc/s cosmic noise had a slowly decaying component, the half-life being of the order of 2 to 3 months.
PA

GOODALL, W. M. On Ionization of F_2 region. Proc. IRE 25, 1414-1418 (1937).

Available data on F_2 region ionization for Peru, Australia, and United States, are analyzed in way that permits separation of effects due to variations in solar ionizing force from effects due to seasonal and annual changes.
EI

GOODALL, W. M. The solar cycle and the F_2 region of the ionosphere. Proc. IRE 27, 701-703 (1939).

This paper presents a method of analysing F_2-region critical-frequency data in a way that shows in a clear cut manner the correlation that exists between monthly average values of these critical frequencies for undisturbed days and solar activity as measured by the central-zone character figures for calcium flucculi. Curves are presented which show for each month

the expected diurnal variation of f^0_{F2} for two values of solar activity. Other curves show for a number of different hours the expected seasonal variation of f^0_{F2} at a constant time of day for the same values of solar activity.
A

GOODWIN, G. L., and J. A. Thomas. Field-aligned irregularities in the E_s region. Scientific Rept. 14, Contract AF64(500)9, Queensland University, Australia, (March 1962). AD-294 700.

A comparison of the known diurnal and seasonal behavior of constant height (E sub sc) and sequential (E sub ss) sporadic-E echoes with that of field-aligned (E sub d) echoes from the E-region indicated that an increase in occurrence of E sub d echoes generally coincided with an increase in occurrence and/or range spreading of E sub sc echoes, but was independent of the presence of E sub ss echoes. A detailed comparison indicated that at night in October and in day- and night-time in December almost all E sub sc clouds detected at frequencies at least down to 2.5 Mc/s have irregularities which are field-aligned.
A

GOODWIN, G. L., and J. A. Thomas. Field-aligned irregularities in the E_s region. J. Atmos. Terrest. Phys. 25, 707-719 (1963).

A comparison of the occurrences of "constant height" sporadic-E (E_{sc}) echoes and field-aligned ($E_s\phi$) echoes from the E-region showed that at certain times of the year at least, there was a significant probability of their simultaneous occurrence. The probability was even more significant when vertical incidence E_{sc} echoes were range spread. It is concluded that the E_{sc} region commonly contains field-aligned ionization.
A

GOUIN, P. Reversal of the magnetic daily variation at Addis Ababa. Nature 193, 1145-1146 (1962).

The magnetic station at the University College of Addis Ababa is situated near the magnetic zero-dip equator and is directly under the influence

of the equatorial electrojet currents. Its position in latitude is geographic, N. 09° 02'; geomagnetic, N. 05° 2; magnetic, S. 0. 5. Consequently, during magnetically quiet days, the daily variation S_q + L of the horizontal component H follows a smooth curve which normally starts with a small dip before sunrise, passes through a maximum of 100–200γ above night-level between 1130 L.T. and 1230 L.T., and then decreases with a slight positive asymmetry towards a night minimum. It is of interest to note that this second minimum could either be a night-level reached shortly after sunset (case A), or simply the dip before the next morning sunrise (case B). In case B, the p.m. negative slope is less steep, but continues regularly until the early hours of the next morning unaffected by sunset or night conditions. In both cases, the H-curve could be slightly distorted either by a strong L-effect, or by the presence of one or two bays during the night. In case B, the general level of the field may be suddenly increased by the presence of a bay, but the gradient of the curve usually remains unchanged.

The vertical component Z does not follow so definite a pattern, being influenced, among other factors by a strong lunar effect and by the position of the Sun north or south of the station.

The declination-curve is of a northern or southern hemisphere type according to the declination of the Sun.

This article reports a drastic change in the characteristics of the daily variation (ΔH, ΔZ, and ΔD) in Addis Ababa during the first week of January 1962. Fig. 1 shows the extreme phases of the phenomenon in H.

The period was magnetically quiet. The sequence of the changes in the daily variation-curves for the three components H, Z and D is shown in Fig. 2, in which the hourly means have been plotted and centred on the half-hours.

The H-curves of December 31, 1961, and January 1, 1962, follow the standard pattern of an equatorial magnetic record as described above. In the morning of January 2, a premonitory dip appeared; such a dip would normally be insignificant, but in this case it marks the beginning of the reversal phenomenon. On January 3 and 5, the H variation-curve is completely reversed with a minimum at local noon; during the first part of January 6 the curve, although distorted, is of equatorial type with a strong electrojet amplification while the second part of the day belongs to a completely different latitude. By January 7 and 8, the disturbance was ended and the H-curves normal.

The Z-curves prior to January 3 are too complex to be evidently significant and therefore are not shown in Fig. 2. The daily Z-variations of January 3 and 6 are clearly of a southern type with a single minimum around local noon while those of January 7 and 8 show three maxima and two minima, a characteristic of quiet days around winter solstice.

The variation in declination on December 31, January 4 and 8, are of

the standard type; those of January 3, 5 and 6 show a high degree of distortion.

Fig. 3 gives the vector diagrams of the daily variation of the total field F projected on the H−Z plane. In this figure appears the normal ratio of ΔH and ΔZ, the variation in amplitude of ΔH during the period concerned, and the variation of the phase between ΔH and ΔZ. The premonitory dip is clearly shown on the vector diagram of January 2; the phase relations between ΔH and ΔZ are completely reversed on January 3 and 5; the reversal in the direction of the field during the afternoon of January 6 is also indicated.

Such a change in the characteristics of the magnetic daily variation, from an equatorial type highly amplified by the electrojet to a type of the middle latitudes, has not previously been recorded at this Observatory. A few instances of a drop in the amplitude of the horizontal component of the daily variation can be found on isolated quiet days, but never such a marked sequence as that of January 1962.

Would this phenomenon be caused by a shift in latitude of the ionospheric currents responsible for the S_q + L daily variation or of the equatorial electrojet itself, or would it simply be an extraordinarily amplified L-effect? The magnetic records for the same period during the following lunation suggest an amplified L-effect. This problem will be dealt with more thoroughly once records from other stations permit the analysis of the phenomenon over a wide area.
Excerpt

GOULD, R. G., and W. R. Vincent. System concepts for a Common-User Radio Transmission Sounding System. Final Rept., SRI Project 3992, Contract SD-119, Stanford Research Institute, Menlo Park, Calif. (Oct. 1962).

This report describes a study of a Common-User Radio Transmission Sounding System (CURTS).

It is demonstrated that oblique ionospheric sounders can find usable frequencies during periods of a disturbed ionosphere and that usable frequencies can be predicted with high accuracy for periods of a quarter of an hour or more during times of average magnetic activity. During both average and disturbed times, a communications circuit operator can use a sounder to improve performance.

A systems operational concept for use of sounders is described and analyzed. It is concluded that common use of sounders is desirable and

G

necessary for purposes of interference reduction, optimum utilization of equipment, and minimum cost.

Problems that have arisen during field tests are discussed, as well as unresolved technical and operational questions.

It is concluded that sounders are a promising operational tool but that certain questions must be settled by additional study and field tests before operational employment of sounders is undertaken.

A

HAGN, G. H., D. L. Nielson, and F. H. Smith. Backscatter literature survey. SRI Project 3311, Contract SD-66, Stanford Research Institute, Menlo Park, Calif. (June 1961).

A survey of the literature pertaining to backscatter is presented in bibliographical form. Authors' abstracts have been included whenever they were available and appeared adequate. The survey is intended to cover the period from the inception of the study of ionospheric backscatter (about 1928) through 1960.

This survey deals mainly with ionospherically propagated backscatter at HF. Some work on terrain return and on direct backscatter from discrete objects is presented, and the major early papers on incoherent (exospheric) scatter from electrons have been included. Material dealing with troposcatter, ionoscatter, forward propagation at HF, and meteoric and auroral echoes has, in general, been excluded.
A

HAGN, G. H. Orientation of linearly polarized HF antennas for short-path communication via the ionosphere near the geomagnetic equator. Res. Memo. 5, SRI Project 4240, Contract DA-36-039-AMC-00040(E), Stanford Research Institute, Menlo Park, Calif. (Aug. 1963).

This report suggests that there is an optimum orientation for linearly polarized antennas used on short ionospheric paths near the geomagnetic equator. Consideration of the magneto-ionic theory and its application to antenna-to-medium coupling problems indicate that aligning such antennas parallel to the earth's magnetic field will maximize signal strength while minimizing polarization fading. Such orientations may intercept less interference than vertically polarized antennas. If this is true, the signal-to-noise ratio would be maximized and the orientation would be truly optimum. Experiments to test these hypotheses are outlined.
A

HAGN, G. H. Absorption of ionospherically propagated HF radio waves under conditions where the QT approximation is valid. Paper presented to Commission III, URSI, Fall Meeting, Seattle, Washington, Dec. 1963.

This paper presents expressions for the absorption coefficients of a plane electro-magnetic wave propagating through regions of a weekly-ionized magneto-ionic medium where the quasi-transverse (QT) approximation (Hibberd, 1962 and Davies and King, 1961) is valid. The QT approximation is most likely to hold on long east-west paths, short equatorial paths (e.g., such as one encounters on short ionospheric paths in Southeast Asia), and at heights near reflection for the ordinary wave. A comparison of absorption on representative paths calculated using absorption coefficients

for the upper and lower sign shows that the upper sign (ordinary wave) suffers less attenuation. When the wave frequency is near the gyrofrequency, the extraordinary wave is greatly absorbed. When the wave frequency is much greater than the gyrofrequency, the expression for the upper sign (ordinary wave), QT approximation, is very nearly the same as the expression for the QL (quasi-longitudinal) approximation; both are very nearly the same as the no-field case. No such simple comparison exists for the lower sign (extraordinary wave). Experiments are presently being conducted in Thailand to test the validity of the absorption coefficient expressions calculated using the magneto-ionic theory.
A

HAGN, G. H., and L. McAfee. Backscatter literature survey. SRI Project 3311, Contract SD-66, Stanford Research Institute, Menlo Park, Calif. (April 1964).

A survey of the literature pertaining to backscatter is presented in bibliographical form. Authors' abstracts have been included whenever they were available. This survey is intended to cover the period 1960 through 1963, updating a previous survey covering the period from the inception of the study of backscatter (about 1928) through 1960, however a few early 1964 references are also included.

This survey deals mainly with ionospherically propagated backscatter at HF. Some work on terrain return and on direct backscatter from discrete objects is presented, and some of the major early papers on incoherent (exospheric) scatter from free electrons have been included. Material dealing with troposcatter, ionoscatter, forward propagation at HF, and meteoric and auroral echoes has, in general, been excluded. Papers dealing with ionospheric disturbances (especially traveling disturbances) have been included.
A

HANNA, N. O. M. The induction of electric currents in a nonisotropic and non-uniform ionosphere. Proc. Math. Phys. Soc. UAR, No. 23, 17-24 (June 1959).

The study of the distribution of the induced currents in a nonisotropic and non-uniformly conducting ionospheric shell for an external inducing magnetic potential of period one day, shows a tilting of the current lines in the direction of the meridians; also the existence of two systems of vortices, one in the positive distribution of current lines and the other in

the negative distribution, symmetrically placed with respect to the equatorial plane. The current is also found to lag behind the inducing potential by a quarter of a period, spherical polar coordinates being used throughout.
PA

HARGREAVES, J. K. An experimental method of estimating F-region collision frequencies. J. Atmos. Terrest. Phys. 25, 300-304 (1963).

In the study of ionospheric radio-wave absorption there frequently is difficulty in separating the relative contributions of the D- and F-regions. In riometer studies, for instance, it is sometimes necessary to apply a correction for the F-region absorption in order to measure absorption occurring in the D-region. However, the necessary information about the effective F-region collision frequency is sparse (Ratcliffe and Weekes, 1960), and attempts to correct for the F-region component have, thus, usually been empirical (Mitra and Shain, 1953; Ramanathan and Bhonsle, 1959; Lusignan, 1960). Steiger and Warwick (1961), in their analysis, took into account the loss of signal due to restriction of the F-region iris with increasing critical frequency. The present note is a further refinement, illustrating how experimental values of the effective collision frequency can be obtained from a comparison of ionosonde and riometer observations made under conditions when the F-region critical frequency approaches the operating frequency of the riometer, i.e. when deviative absorption is important in the F-region.
Excerpt

HARWOOD, J. Some observations of the occurrence and movement of sporadic-E ionization. J. Atmos. Terrest. Phys. 20, 243-262 (1961).

A rotating-aerial back-scatter sounder has been used at 17 Mc/s to examine the location, approximate size, and movements of clouds of sporadic-E ionization for the period May—August 1959, as part of a European co-operative experiment involving a number of vertical-incidence sounding stations. Clouds, of average diameter about 200 km and average duration 2 hr, were seen more frequently to the south than to the north. One third of them drifted, predominantly towards the south-west, at a mean speed of 60 m/sec. There was good correlation between the

occurrence of back-scatter echoes propagated by way of E_s clouds, one-way propagation over a 700 km path by the same means, and the occurrence of high E_s critical frequencies at a few vertical incidence sounders. To account for a lack of correlation between other drift measurements and E_s cloud movements, it is suggested that the former are based on the fine structure of the cloud, whereas the latter depend on observation of the main cloud boundaries.
A

HASEGAWA, M. On the zonal components of the diurnal variations of terrestrial magnetism. Proc. Imp. Acad. Japan 13, 69-73 (1937).

As I have pointed out in a previous paper, if we determine the instantaneous values of the diurnal variations of terrestrial magnetism over the earth, we find that the integration of X and Z components along latitude circles, (on which we have well distributed observatories) gives finite residuals which can hardly be regarded as being within the range of errors. Fig. 1, reproduced from the former paper, shows the instantaneous values along the latitude circle 20° N. The residuals in the Y component are far smaller than those in the other components.

The mean integral values along circles of every 15° of latitude, are calculated for every 2 hours on IX, 23 and for every 4 hours on IX, 24, 1933, by constructing charts of magnetic potential such as were shown in the former paper.
Excerpt

HASEGAWA, M. Geomagnetic distortion in region F2, its nature and origin. Proc. Mixed Commission on the Ionosphere, Brussels, 16-18, Aug. 1954, 43-48 (1954).

Summary of recent Japanese work on the interpretation of F2-layer distortion in terms of vertical electron drift. Calculated diurnal variations of maximum electron density and height of the F2-layer at Huancayo based on geomagnetic data agree well with the same parameters obtained by Martyn from ionospheric data. Other possible causes of F2 anomalies are mentioned.

Appendix. Provisional report on geomagnetic distortion of the F2 region on the magnetic equator. M. Hirono and H. Maeda.

The velocity of vertical electron drift at a height of 300 km on the magnetic equator due to the variations of electrical conductivity of the "S_q-layer" has been calculated as a function of local time. The effects

of this on an ionized region are briefly considered. The required electrical conductivity of the E-region seems to fit radio estimates for the magnetic equator.
PA

HECKMAN, H. H., and G. H. Nakano. East-west asymmetry in the flux of mirroring geomagnetically trapped protons. Lawrence Radiation Laboratory, University of California, Berkeley (13 Dec. 1962).

The visual detection of geomagnetically trapped protons in the region of the South Atlantic magnetic anomaly is reported. Protons of energy ≥ 57 Mev were recorded in nuclear emulsions during a 65-orbit, oriented flight of a satellite recovered on September 1, 1962. An east-west asymmetry in the flux of geomagnetically trapped protons was observed, confirming an effect predicted by Lenchek and Singer. From measurements of the east-west asymmetry, a value of 62.0 ± 5.0 km was obtained for the scale height of the atmosphere at 364-km altitude.
STAR

HEISLER, L. H. A panoramic ionospheric recorder for the study of travelling disturbances in the ionosphere. Austral. J. Appl. Sci. 6, 1-7 (1955).

A description is given of an ionospheric recorder covering the frequency range 1 to 15 Mc/s with a fast scan of 7-1/2 or 15 sec. New circuits have been evolved and an unconventional method of recording used to make the equipment especially suitable for the study of movements in the ionosphere. A panoramic display of each scan is provided and this is used for visual monitoring of the recording programme.
A

HEISLER, L. H. Anomalies in ionosonde records due to travelling ionospheric disturbances. Austral. J. Phys. 11, 79-90 (1956).

Anomalies which frequently appear on ionosonde records of the F region during the passage of travelling disturbances are classified into four main types; and the diurnal and seasonal distribution of their occurrence is discussed.

It is suggested that the type of anomaly appearing on records depends on the ion density distribution at a height of about 200 km, which appears to be an upper bounding surface for the mode of travel of disturbances.

A particular study has been made of winter disturbances. These are found to be so frequent that they affect all ionosonde records obtained during this season. They travel distances of at least 3000 km with fronts possibly broader than 1000 km. Attempted correlation with geomagnetic storminess was unsuccessful.

Information is also presented on similar disturbances observed in North America.

A

HEISLER, L. H., and J. D. Whitehead. Longitude effect in temperate zone sporadic E and the earth's magnetic field. Nature 187, 676-677 (1960).

A recent study of the occurrence of sporadic E has shown that the percentage of the time $f_0E_s > 5$ Mc./s. exhibits a marked longitude effect, having a maximum (~ 30 per cent) over south-east Asia and minima over South Africa (~ 3 per cent) and the north-east part of the United States (~ 6 per cent). That the effect is real, and not due to differences of equipment sensitivity, has been confirmed by very high-frequency forward scatter experiments over the Caribbean and the Philippines. The suggestion was put forward that this longitude effect may depend in a complex manner on both geographical and magnetic latitudes or may be due to meteorological effects.

The purpose of this communication is to point out that the horizontal component of the Earth's magnetic field has a similar variation at the Earth's surface. In Fig. 1 the percentage of the time $f_0E_s > 5$ Mc./s. for the thirty-one ionosonde stations mentioned by Smith is plotted against the magnitude of the horizontal component. Results from both northern and southern hemispheres follow the same pattern.

That it is the horizontal component which is correlated with sporadic E appearances is confirmed by plotting the percentage time $f_0E_s > 5$ Mc./s. against the total intensity of the Earth's field (Fig. 2). There is no correlation between the two. There is some correlation between the occurrence of sporadic E and magnetic dip though this is almost entirely due to their correlation with the horizontal component.

It is of interest to inquire which of the various theories put forward to account for sporadic E depend only on the horizontal component of the Earth's magnetic field. Ionization by neutral particles or meteors does not depend on magnetic field at all but ionization by charged particles may be confined to a narrow region in the presence of a magnetic field. The total intensity, however, seems to be of importance here. Movement of

existing ionization by winds or electric fields seems to be the most likely source of sporadic E, and is being studied further.

HEISLER, L. H., and J. D. Whitehead. The interpretation of F2 critical frequency measurements. J. Atmos. Terrest. Phys. 22, 186-191 (1961).

During winter daylight hours changes in f_0F2 are almost continuous due to the presence of travelling ionospheric disturbances. It is suggested that variation in hourly values of f_0F2 from day to day on magnetically quiet days is due mainly to this cause and it is shown that these values are only reliable to ± 0.5 Mc/s. The resultant error in estimated maximum usable frequencies has been determined. Critical frequencies as read from ionogram records are not true vertical incidence values but are reflected at an angle θ from the vertical because of sloping isoionic contours. This angle has been estimated as well as the amount by which average measured values of f_0F2 must be decreased to give real vertical incidence values of f_0F2.
A

HEISLER, L. H., and J. D. Whitehead. Rapid variations in the sporadic-E region. J. Atmos. Terrest. Phys. 24, 753-764 (1962).

Ionograms taken every 7.8 sec have been analysed to see how rapidly the sporadic-E parameters, f_0E_s and f_bE_s, change with time. Normal echo fading causes changes of up to ~ 0.1 Mc/s from one record to the next; the structure of the sporadic-E clouds leads to a slower variation with a quasi-period of about 1 hr, and amplitude of the order of 0.5 Mc/s. Averaged over 2-1/2 min, f_0E_s and f_bE_s have root mean square rates of change of 0.1 Mc/s per min. f_0E_s increases a few minutes before and decreases a few minutes after corresponding increases and decreases of f_bE_s. On two occasions a decrease in f_0E_s results from a break-up of the trace on the ionogram rather than a steady decrease. It is possible that these two effects are the result of diffraction from the edges of ionization clouds and from a small cloud respectively.
A

HEISLER, L. H., and J. D. Whitehead. The correlation between the occurrence of sporadic-E and the horizontal component of the earth's magnetic field. J. Atmos. Terrest. Phys. 26, 437-444 (1964).

A consideration of IGY data and earlier data on the occurrence of sporadic-E in the temperate zones supports the authors' previous conclusion that the occurrence of sporadic-E is correlated principally with the horizontal component of the earth's magnetic field. The analysis also suggests that temperate zone sporadic-E tends to occur more frequently

at high sunspot number and also occurs equally over land and sea; these suggestions disagree with the conclusions reached by other workers.
A

HENDERSON, C. L. Seasonal and latitude variations of noon bearings of E-region drifts. J. Atmos. Terrest. Phys. 24, 663-666 (1962).

Examinations of further Lower Hutt noon data show that the E-W component does not have a simple sinusoidal variation with seasons. A seasonal plot of bearings at Cambridge and Lower Hutt confirmed the common trend to the Earth in summer and the different behavior in winter. The possibility of a latitude effect in winter was suggested. Summer plots of bearings against geographic, geomagnetic and dip latitudes were similar in all three cases. Winter plots showed that some magnetic latitude control was present, since the distributions versus geomagnetic and dip latitudes showed significantly less spread and both varied in a similar manner. A diagram giving the variation of E region noon bearings with geomagnetic latitude is presented. It is seen that in winter, over latitude range 14−66°, there is a steady change of bearing with latitude. The same group of data when plotted against magnetic dip covers a latitude range of 20−60°.
MGA

HENDERSON, C. L. E-region drifts at Lower Hutt. IN: Proc. International Conference on the Ionosphere, London, 1962, 342-347 (The Institute of Physics and the Physical Society, London, 1963).

Discussion of observations presented in the form of average N-S and E-W components of each season of the period from 1952 to 1958. The seasonal observations for the separate years are found by Fourier analyses over the daytime period, and partly for the full 24 hours. The prevailing drift is found to have a N-S component invariably to north. This motion toward the equator is common to nearly all latitudes, while the drift to the east in summer is universal. The 24-hour harmonics have very consistent phases in summer. The N-S components are toward the nearer poles at about 1100 hours local time for all latitudes. The E-W components are mostly to the east near 1130 hours for middle and high latitudes. The 12-hour harmonics observed locally from both daytime and 24-hour data are in good agreement. Phases in summer are very stable. The N-S summer phases are constant over middle and high latitudes, while the winter and equinox phases very linearly with latitude. The 8-hour harmonics exhibit a secular N-S phase change in summer. The phases are generally in good

agreement over a wide latitude range. The results are compared with analyses from other stations.
Source unknown

HERBSTREIT, J. W., and W. Q. Crichlow. Measurement of factors affecting jungle radio communication, Rept. ORB-2-3, Operational Research Staff, Office of the Chief Signal Officer, Washington, D.C. (1943).

Field strength measurements were made on 2005 kc, 2975 kc, 44 mc, and 98.8 mc to determine the attenuation of radio waves through heavy jungle. The attenuation was found to be so great that for communication greater than approximately one mile, the ground wave which is normally employed for these ranges, is practically useless. It requires powers of the order of 200 times the power of the sets tested to give a ground wave range of 2 miles. It is shown that communications over greater distances than one mile necessitate either (1) treetop or hill to hill transmitter and receiver sites at very high frequencies so that the transmission path is mainly above the top of the jungle; or (2) use of sky wave transmission at high frequencies wherein the transmission path is up to the ionosphere and back to the ground. The use of ionosphere predictions as a guide in the selection of proper frequencies for sky wave transmission is urged.

Measurements of "atmospheric" noise level were made on the frequencies 2005, 2700, 4160 and 5975 kilocycles to obtain quantitative data on the signal intensity required for satisfactory communications for correlation with predictions of required signal intensity made on the basis of thunderstorm data. The method of measuring average atmospheric noise level is described in detail and it is recommended that further noise measurements of this type be made in areas in which future operations are contemplated.
A

HERBSTREIT, J. W., and W. Q. Crichlow. Measurement of the attenuation of radio signals by jungles. J. Res. Radio Sci. NBS/URSI, 68D, 903 (Aug. 1964).

Recent interest in jungle communications has indicated the desirability of publishing quantitative field strength measurements made in jungles by the authors during World War II. The jungle attenuation of radio signals is so great that for satisfactory communications over distances greater than one mile, skywave propagation or elevated antennas should be employed.

HERMAN, J. R. Solar-flare effects on 2.5 and 5.0 Mc/s atmospheric radio noise. J. Geophys. Res. 66, 3163-3167 (1961).

Analysis of radio noise records from Kekaha, Hawaii, and Ohira, Japan, during 75 solar flares occurring during August, September, and October 1958 reveals a positive relationship between short-time noise power decreases and solar flares. The most significant noise fadeouts associated with flare eruptions occurred with the sun over one of the major noise centers contributing to the noise level at the measuring station. Maximum noise decrease of 18 db was observed on 5.0 Mc/s at Kekaha when the sun was over the East Indies noise center, just after sunset at the receiver.
A

HERRINCK, P. Tides in the F_2 ionospheric layer. Nature 184, 1055-1056 (3 Oct. 1959).

From five years observations (1952-1958) at Leopoldville-Binza, an harmonic analysis of the mean diurnal variation of ym is obtained. The analysis shows a prominent first harmonic, associated with the following oscillations listed in order of decreasing amplitude: 8 hr, 4.8 hr and 12 hr. Half hour amplitudes are tabulated and eight hour oscillation is graphically represented. The conclusions drawn from harmonic analysis of the diurnal variation for each calendar month using mean values over five years are listed.
MGA

HERRINCK, P. Characteristic Features of world distribution of F2 layer maximum ionization. IN: Beynon, W.J.G., ed. Some Ionospheric Results Obtained During the IGY. Proc. Symposium URSI/AGI Committee, Brussels, Sept. 1959, 14-17 (Elsevier Publishing Co., New York, 1960).

Charts of the F2 layer maximum ionization distribution over the world have been delineated by compiling data from World Data Center C-I at Slough (England). It has been established that the ratio between high and low "sunspot number electron density" varies for an individual station according to the hour of the day. The relative daily average of the rate of increase of maximum electron density, when the sunspot number increases from 10 to 100, has been charted in a map exhibiting the distribution of maximum ionization over the world. World maps of F2 critical frequencies

have been drawn for every hour for March, June, Sept. and Dec. The results show a discontinuous daily shift of position of the world maximum of the F2 layer maximum electron density which could be explained by a peculiar behavior of the magnetic and electrical fields surrounding the Earth.
Source unknown

HERRINCK, P. Analysis of the maximum electron density of the F_2 layer at Leopoldville-Binza. IN: Beynon, W. J. G. ed. Some Ionospheric Results Obtained During the IGY, Proc. Symposium URSI/AGI, Comm., Brussels, Sept. 1959, 18-24 (Elsevier Publishing Co., New York, 1960).

Before drawing the conclusions of this analysis let us summarise the facts.

The maximum electron density of the F2 layer over Leopoldville has the following peculiarities:

(1) A global semi-annual variation in phase with the variation of magnetic activity which geomagneticians have good reasons to believe to be due to a corpuscular effect.

(2) The highest percentage of the six-month variation occurs at night almost simultaneously with the maximum of electron density.

(3) A diurnal variation with a pronounced maximum situated as late as between 2100 h and 2300 h L.M.T.

(4) A very high rate of increase with sunspot numbers of the electron density between 1800 h and 2400 h L.M.T., and low values for mid-day.

(5) A "saturation effect" noticeable with increase of sunspot number between 7000 h and 1900 h U.T. A similar effect also appears in the E layer. For the remaining hours the relationship is linear.

These points are hard to explain by the sole use of a drift theory, although some drift must occur.

What is important, is that rding to the time of the day, one of two different types of phenomenon b nes preponderant. The high rate of ionisation at night, the six-monthly variation, the different character of sunspot influence during the day and at night, may be readily explained by an incoming flux of corpuscles of low energy which is almost completely lost in ionisation processes in the F2 layer. These particles cannot be considered as cosmic rays but must originate from regions in the proximity of the earth, and may not be the only acting agency. If the view expressed here is correct, the geomagnetic control of the F2 would appear to be due partly to corpuscular deflection and partly to Martyn's drift mechanism. A second paper in these Proceedings gives further evidence from a different point of view.
MGA

HERRINCK, P. Study of the evolution of the ionospheric F_2 layer at Leopoldville-Binza. Ann. Geophys. 16, 77-87 (1960). (In French.)

The present investigation of the maximum electronic density of the F_2 layer shows: (1) a semi annual global variation, in phase with the variation in magnetic activity; (2) a marked semi annual variation between 09 and between 23 and 02 hours U.T. and a marked annual variation for the remaining hours; (3) a considerable rate of increase with sunspot numbers between 18 and 24 hours L.M.T.; (4) a maximum between 21 and 23 hours corresponding with a maximum of the half thickness. Owing to the difficulties encountered in explaining these particularities only by the action of photonic ionization and drift, it seems justified to consider extra ionization due to corpuscles accelerated in a region near to the earth.
PA

HERRINCK, P., and J. Goris. Evolution of the maximum electron density of layer E at Leopoldville-Binza. Geophys. Pura Appl. 45, 153-166 (1960).

Data relative to the E layer over Leopoldville are analyzed for the period between the end of the last solar cycle and the maximum of the present one (Feb. 1952 to Dec. 1958). It is shown that the diurnal variation of the maximum electronic density follows the Chapman law very well; in logarithmic coordinates the regressions are linear. The two parameters of this regression, the ordinate at the origin (logarithm of the maximum density for a zero sun-height) and the slope, are expressed in function of the Wolf number R. Their seasonal variations are studied theoretically and from the actual data; it is shown that the seasonal variation of the electron density is essentially due to the geometry of the Earth-Sun system.
MGA

HEWISH, A. The diffraction of radio waves in passing through a phase-changing ionosphere. Proc. Roy. Soc. A 209, 81-96 (1951).

The radio waves from 'radio stars' may suffer irregular phase changes in passing through the terrestrial ionosphere, so that when they reach the earth's surface they produce a disturbance in which both amplitude and phase vary over the ground. In this paper it is assumed that the wave emerges from the ionosphere with amplitude constant but with phase varying across its wave-front, and deductions are made about the diffraction pattern produced at the ground. It is shown how, from a knowledge of the

way in which phase and amplitude vary at the ground, it is possible to deduce the average magnitude of the phase deviations produced by the ionosphere and their lateral extent. It is also shown how an investigation of the diffraction patterns produced by different wave-lengths may lead to an estimate of the distance of the effective diffracting screen from the plane of observation. Experiments to determine the diffraction pattern formed at the ground by waves emitted from a radio star are described in outline, and an application of the theory to some of the observations indicates that the ionospheric irregularities have a lateral extent of the order of 5 km. and are sufficient to cause a phase deviation of 1 to 2 radians for a wavelength of 6.7 m.
A

HIGGINS, T. P. Determination of the earth's conductivity by measurements at the surface. I. Linearly varying conductivity. Mathematical Note 236, Boeing Scientific Research Laboratories, Seattle, Wash. (March 1961). AD-255 865. [For reference at ASTIA Hq. only. ASTIA does not furnish copies. A copy may be obtained from the author (1961).]

Maxwell's equations are determined for a transiently excited magnetic dipole over a two layer flat earth in which the conductivity varies arbitrarily as a function of depth. The general boundary value problem is solved formally using Laplace and Hankel transform techniques. A complete approximate solution is obtained for constant conductivity and for conductivity which varies as a linear function of depth.
ASTIA

HINES, C. O., and E. N. Parker. Statement of agreement regarding the ring-current effect. J. Geophys. Res. 65, 1299-1301 (1960).

An earlier disagreement between the authors on the rate at which a decrease in field can be propagated through the earth's exosphere is outlined with reference to two extreme models. A new model is described, explaining the origin of the ring current, and on this agreement has been

reached. A rapid propagation of the disturbances produced is consistent with the main phase of a geomagnetic storm.
PA

HINES, C. O. Symposium on the Exosphere and Upper F region: Summary of proceedings. J. Geophys. Res. 65, 2563 (1960).

A decade ago it was commonly believed that the hydrostatically supported atmosphere of the earth decreased in density to very low values within a few hundred kilometers of the earth's surface. This view was based on assumed thermodynamic temperatures of only a few hundred degrees, applied to the oxygen and nitrogen atoms which dominate at the heights concerned. Similar considerations indicated a corresponding confinement of the overlying exosphere—of the region, that is, where the constituent neutral atoms are free from significant collisions with one another, and where instead their motions follow ballistic trajectories. As a consequence of these conclusions, the total extent conceived for the earth's sensible gaseous mantle was limited to heights of a few thousand kilometers at most.

These views are, of course, now totally revised, and regions of the earth's atmosphere out to several earth radii are currently subject to intensive study by a wide variety of techniques. In order to provide a forum for the discussion of recent results and even newer speculations, a symposium on the exosphere and upper F region was sponsored by Commission III of the United States National Committee of URSI at the 1960 spring meeting in Washington. A number of formal presentations were given, and they were accompanied by several informal contributions and much discussion. The present paper constitutes a report on the proceedings.

The prepared contributions fell roughly into four broad categories, all concerned primarily with quiescent conditions and with major constituents. First, the general features of the exosphere and upper F region were discussed, and the various neutral particles and positive ions that dominate in successive height ranges were debated. There followed a number of papers concerning electron densities in and above the F region as revealed by magnetoionic refractive effects imposed on radio transmissions from rockets and artificial satellites. Refractive effects can also be applied to a study of the integrated electron content, even when detailed densities cannot be derived, and papers pursuing this line of attack came next. Finally, a group of papers treated recent developments in the study of electron densities and electron-ion temperatures as measured by means of the incoherent scatter of radio waves from individual electrons. These four groups of papers, together with the corresponding discussion and related material, are reviewed in the following four sections and summarized in a fifth.

In the review, no attempt is made at an encyclopedic abstract of the proceedings. Instead, the salient and interrelated points of the entire discussion are emphasized at the expense of detail, and are even expanded upon in certain cases. In order that some of the more detailed aspects of the proceedings should be conveniently available, however, the various contributors were invited to provide summaries of their material, or full manuscripts if publication was imminent anyway. The papers that were forthcoming before the publication deadline are printed immediately after this report.
Excerpt

HINES, C. O. Geomagnetism and the ionosphere. IN: Proc. International Conference on the Ionosphere, London, 1962, 103-114 (The Institute of Physics and the Physical Society, London, 1963).

Interactions between the geomagnetic field and the ionosphere are reviewed. These occur on the largest scale, under the influence of the interplanetary plasma, to determine the overall configuration both of the field and of the distant ionosphere. They include rotational interactions on the same scale, which serve to maintain much and perhaps all of the ionospheric medium co-rotating with the earth. On a somewhat smaller but still global scale they include tidal and storm phenomena, which alter both the field and the ionospheric characteristics and which probably play a major part in auroral and related phenomena. They occur in more localized fashion within ionospheric irregularities of various types, and on a shorter time scale in magnetically dominated waves, both hydromagnetic (in micropulsations) and magneto-ionic (in v.l.f. emissions). Salient features of all these interactions are discussed briefly, following an introductory review of the hydromagnetic and equi-potential techniques that permit a succinct description of most of them.
A

HIRONO, L. M. On the influence of the Hall current to the electrical conductivity of the ionosphere. J. Geomag. Geoelec. 2, 1-8 (May 1950).

It is suggested that the effect of the electric field produced by the vertical component of the Hall current, together with the smaller effect due to its horizontal component, may construct, along the magnetic equator in the ionosphere, a narrow region, in which the conductivity near the level of the E layer is much greater than in the other latitudes. This

result is considered to be in accordance with the latitude distribution of the range of diurnal variation of terrestrial magnetism.
PA

HIRONO, M. On the influence of the Hall current to the electrical conductivity of the ionosphere II. J. Geomag. Geoelec. 2, 113-120 (Dec. 1950).

It is shown that there is a narrow region along line of zero dip near the E layer, of about 15° of latitude wide in which conductivity is very great, as a result of polarization by the Hall current. The effect of this belt is discussed by the dynamo theory, giving the result that this belt will cause enhanced diurnal variation of magnetic field near the geomagnetic equator.
PA

HIRONO, M. A theory of diurnal magnetic variations in equatorial regions and conductivity of the ionosphere E region. J. Geomag. Geoelec. 4, 7-21 (April 1952).

The theory reported by the author (1950) is discussed further in detail. A dynamo theory for the E region with anisotropic conductivity, which is linked by highly conductive lines of magnetic force to the F region, is examined. A case that the E layer only makes a tidal oscillation, which produces observed lunar diurnal current system, is calculated. It is found that, in middle latitudes, the induced polarization field in E-W direction due to the Hall current is greater than that due to the direct current, and the vertical drift of the F2 layer due to this polarization field seems to be adequate for the observed F2 lunar variation. According to the present theory, conductivity of the E region at the magnetic equator decreases with increase of the main magnetic field, and the distribution of range of magnetic variations along the magnetic equator, reported by Egedal, seems to support this relation.
PA

HIRONO, M. A theory of diurnal magnetic variations in equatorial regions and conductivity of the ionosphere E region. 2. J. Geomag. Geoelec. 5, 22-38 (1953).

In succession to Pt. 1, the electrical conductivity of the E region is calculated in some detail for two atmospheric models. It is shown that the factor, by which the tidal oscillation of the E region exceeds that at ground level, should be less than 10^3, in order to give the observed lunar magnetic variation. The calculated lunar vertical movement of the E region is nearly in phase with that observed in South England and nearly opposite at Canberra. A possibility is shown that the calculated lunar

vertical movement of the F2 region roughly agrees with that observed. It is suggested that the vertical drifts of the F2 region near the magnetic equator may be much greater than those in the other latitudes.
MGA

HIRONO, M., and H. Maeda. Geomagnetic distortion of the F_2 region on the magnetic equator. J. Geophys. Res. 60, 241-255 (1955). Similar material was published in J. Geomag. Geoelec. 6, 127-144 (1954).

The direct relation between the geomagnetic S_q-variation and the vertical electron drift of the F2 region on the magnetic equator is examined.

It is shown that the electric field in the F2 region accompanied by S_q electric current produces the vertical drift which is sufficient to interpret the main features of the anomaly of the F2 region on the equator. It is to be noticed that the main term of the drift velocity is diurnal. The daily variations of the maximum electron density and its height in the F2 region are calculated under consideration of the vertical electron drift for the reasonable distribution of decay coefficient with altitude inferred by observed results. The calculated F2 daily variations have a striking resemblance with those observed near the magnetic equator. When the ion production takes its maximum value at about 200 km, there appears a lower secondary maximum of electron density which agrees well with the observed F1 layer.

The change of characteristics of daily variations of the F2 region with the sunspot-cycle is likely to be accounted for by a slight shift of the phase of the drift.
A

HIRONO, M., and H. Maeda. Characteristics of the F2 layer on the magnetic equator. Rept. Ionosphere Res. Japan 9, 86-94 (1955).

The eastward component of the electric field producing the S_q current on the magnetic equator produces the vertical drift of the F2 region at the same time, and the main term of the drift velocity is diurnal. The calculated daily variations of the F2 region, under consideration of this drift, have a striking resemblance with those observed near the magnetic equator.

The difference of the effective conductivity of the E region in E-W direction for the two atmospheric models (a_1) and (b) is fairly small, hence does not give rise to an appreciable difference of the estimation of the drift velocity for the two models. The present result, therefore, is substantially correct for the model (b) in Part IV on the magnetic equator.
Excerpt

HIRONO, M. Effect of gravity and ionization pressure gradient on the vertical drift in the F2 region. Rept. Ionosphere Res. Japan 9, 95-104 (1955).

In Pt. 4, the effect of gravity and ionization pressure gradient is examined in relation to the vertical drift by electrodynamic force in the F2 region. It is found that if the number density of the gas at 300 km level is not much less than 10^{10}/cc the semi-diurnal variation of the h_mF2 can be interpreted by drift theory.
N

HIRONO, M., H. Maeda, and S. Kato. Wind systems and drift motions in the ionosphere deduced from the dynamo theory. J. Atmos. Terrest. Phys. 15, 146-150 (1959).

Since the analyses and theoretical researches of Martyn (1947) and others it is increasingly evident that the ionization drift due to electrodynamic forces may produce a number of anomalies in the ionosphere. In recent years the equatorial anomaly of the F2-region was studied (Maeda, 1953; Hirono and Maeda, 1954) and it was shown that the main part of the anomaly can be interpreted by vertical ionization drift accompanied by solar magnetic variation. These results suggest that many other ionospheric anomalies may be interpreted by drift due to the current system producing the daily magnetic variation. The dynamo theory of the ionosphere has been investigated by many workers, but most problems were unsolved as regards daily variation of the anisotropic electrical conductivity. An attempt to solve these problems is presented.
PA

HIRSH, A. J., and R. W. Knecht. On the mean temporal variations of electron density at a fixed height in the F region. J. Geophys. Res. 67, 595-600 (1962).

Monthly mean values of electron density obtained at 280 km over Puerto Rico, from ionospheric vertical soundings, have been studied for the period February 1959 to January 1960.
JPL

HORNER, F. The reception of atmospherics at high frequencies. J. Atmos. Terrest. Phys. 4, 129-140 (1953).

Observation of the amplitudes of atmospherics received in the high frequency band offers a possible method of assessing the distances of their sources. In a preliminary investigation of the potentialities of the technique, atmospherics have been recorded simultaneously at two frequencies in the upper part of the h.f. band. Reception would be expected at both frequencies from sources within ground-wave range (about 100 km). At rather greater distances, such that the receiving point is in the skip zone for both frequencies, no reception should be possible. There should then be a zone from which there should be reception on the lower frequency only, and at greater distances energy should again be received at both frequencies.

The preliminary results conform generally with this pattern, and the boundaries of the various zones are in agreement with the ionospheric data derived from vertical incidence soundings. The sources of the atmospherics observed were located by use of the network of direction finders operated by the Meteorological Office. It is concluded that the technique forms a basis for routine estimation of the distances of storms and merits further examination to determine more precisely the accuracy which can be achieved and to overcome certain practical difficulties in the observations.

A

HRB-SINGER INC. A study of the phenomenon of transequatorial propagation. Rept. 262-R-1, HRB-Singer, Inc., State College, Penna. (1961).

No abstract available.

HULBURT, E. O. Ionosphere, skip distances of radio waves, and propagation of microwaves. Proc. IRE 23, 1492-1506 (1935).

Detailed description of ionosphere given, based on recent measurements of National Bureau of Standards and Department of Terrestrial Magnetism of Carnegie Institute; from ionosphere data, skip distances of

radio waves are calculated for temperature and tropical zones, with diurnal and seasonal changes.
EI

HUMBY, A. M. Equatorial sunset effect. Wireless World 65, 343-345 (1959).

Several examples are given of a propagation anomaly associated with communication links having terminals in equatorial areas. During years of high solar activity it has been found that for equinox months there is marked azimuthal scattering of signals for about two hours near local sunset at the equatorial terminal, making communication extremely difficult. It seems probable that this effect is related to the disintegration of the F2 layer observed at Singapore near local sunset during equinox months [B.W. Osborone, J. Brit. Instn. Radio Engrs., Vol. 12 (Feb. 1952)].
EEA

HUNTLEY, H. E. Radio-astronomy in the tropics. Nature 172, 108 (1953).

In January 1952, the Physics Department of the University College of the Gold Coast brought into operation a radio-astronomy observatory at Achimota, about seven miles from Accra. Its situation gives the station certain advantages. Unlike stations in higher latitudes, its proximity to the equator makes it possible to survey both the northern and southern celestial hemispheres and to observe the sun at zenith angles which are relatively small throughout the year.

The station's equipment includes a twin aerial array forming an interferometer, each array consisting of eight horizontal full-wave dipoles with ground screen, the spacing between the arrays being 30λ ($\lambda = 6.7$ m.). Preamplifiers are provided at each aerial array to neutralize attenuation losses in the cables and increase the signal/noise ratio. The line joining the arrays being in the east-west direction, the collimation plane contains the meridian. The interference pattern is such that the angular separation of the maxima or minima of central lobes is about 2° in Right Ascension.

The receiver and amplifiers incorporate the phase-changing switch described by Ryle. This delicately adjusted unit was constructed by skilled African mechanics in the science workshops of the University College under the supervision of Fr. J. R. Koster, a lecturer in the Physics

Department. The output of the receiver is recorded by an Evershed and Vignoles duplex recorder which employs a siphon pen writing on a clock-driven paper strip, the speed of which can be varied within wide limits.

The construction and maintenance of a radio-astronomy observatory in the tropics occasion certain difficulties which are not encountered in temperate climes. All wood associated with the aerials must be impregnated with creosote against the ubiquitous white ant. Tropical undergrowth which would speedily obliterate the ground screens requires frequent attention. To meet the danger of flooding as a result of tropical rain storms, the hut which houses the receiving equipment is built on piles. Thunderstorms are of such frequency and violence at certain seasons that the register shows little more than a continuous record of lightning flashes. The tropicalization of electronic apparatus is obligatory. Even so, there has been a disappointing series of failures of components, particularly transformers, followed by an unavoidable delay in repairs since replacements must be obtained from overseas.

In certain respects, however, this tropical station has advantages. Such excellent wood as African mahogany is immediately available and cheap. Unskilled labour is plentiful and inexpensive. The African 'lord of the manor' demands only a token rent for the land occupied by the station. There is, moreover, a latitude of choice of pitch which makes the avoidance of man-made electrical interference relatively simple.

The current programme of work in the observatory includes the hour-by-hour recording of ionospheric (F-layer) disturbances of radiation received from radio stars. It has already become clear that at certain seasons the incidence of these disturbances is more frequent in tropical than in temperate latitudes. It was a cause of some surprise that they are often of such violence as to obliterate almost entirely the radiation of so conspicuous a radio star as that in Virgo. The sun's activity at noon is of course included in the daily record, so that sunspots and such solar flares as are active at midday are under observation.

Excerpt

HUTTON, Rosemary. Regular micropulsations of the earth's field at the equator. Nature 186, 955-956 (1960).

The diurnal variation of occurrence of regular pulsations, pc, of the Earth's magnetic field has been studied by many workers and it has been found, in all the cases reported, that the phenomenon is predominantly a day-time one. Typical of the results of magnetic measurements are those obtained in Germany by Angenheister, for periods of 30–60 sec., which

have a maximum frequency of occurrence at 10–12 hr. L.M.T. The measurements of Earth currents, obtained in the U.S.S.R. by Mme. Troitskaya, are representative of that experimental approach and they show a maximum frequency of occurrence around 11–13 hr. L.M.T. Most of the results reported have been confined to mid-latitude stations.

At the symposium on "Rapid Variations of the Earth's Field" held at Utrecht in September 1959, I gave a brief report of an analysis of records of Earth currents obtained at Legon, Ghana (lat. 5° 38', N., long. 0° 11' W.). This analysis indicated that, at this station, regular pulsations of Earth currents occur during the night as well as during the day and, in fact, that the maximum frequency of occurrence for the whole day is at approximately 18–20 hr. G.M.T. The diurnal variation of frequency of occurrence of regular pulsations, pc, for all days, is shown in Fig. 1a, which was the result of an analysis of records of Earth currents obtained between October 1957 and December 1958. More recently, analysis of magnetic records obtained from an induction magnetometer, recording dH/dt at the same station, has shown a similar night-time occurrence of regular pulsations, in addition to the day-time occurrence normally expected. The results of this analysis, which was made for the months of May, June and July 1958, are given in Fig. 1b, together with the results obtained from records of Earth currents for the same 3 months. Both graphs show three maxima, occurring at 6 hr., 12 hr. and 20 hr., and in each case the night-time maximum is the greatest. In fact, there is approximately a 50 per cent chance that regular pulsations will occur between 19 and 21 hr. It is probable that the difference in level of frequencies of occurrence in the two cases is due partly to the different sensitivities of the telluric and magnetic recording systems, and partly to the fact that the Earth-current records and magnetic records were examined by the same observer at different times. A separate study has also been made of the degree of subjectivity in the examination of records for the occurrence of these regular pulsations, by having three observers independently analyse the same records. In all cases, the results gave rise to graphs of very similar form to that in Fig. 1a, but the mean value of frequency of occurrence differed from one observer to another, a factor which was not of primary importance in the present study.

This analysis of both telluric and magnetic records and the independent examination of records by three observers confirms the existence of regular pulsations, pc, during night-time as well as during the day, in the equatorial region. An example of these night-time pulsations, on both Earth-current and magnetic traces, is given in Fig. 2.

The Earth-current results have been further analysed to give the diurnal variation of occurrence of regular pulsations for quiet days only and for different seasons of the year and the results compared with a similar study of results from Tamanrasset (long. 22° 48' N., lat. 5° 31' E.). Two of the main deductions which may be made from this

investigation, which will be reported more fully elsewhere, are: (1) that the frequency of occurrence of regular pulsations at night is greater at Legon than at Tamanrasset; and (2) that, for quiet days, in the interval 0–14 hr., the frequency of occurrence of regular pulsations at Legon is almost the same as that at Tamanrasset. In both cases there is good agreement in this time interval, with the occurrence of the phenomenon at other stations.
Excerpt

HUTTON, Rosemary, and R. W. H. Wright. Diurnal variation of earth currents at the equator. J. Atmos. Terrest. Phys. 20, 100-109 (1961).

Earth current measurements made at Legon, Ghana (5° 38' N, 0° 11' W) are analysed for a period of 15 months. From the analysis, the mean diurnal variation is found to be 180 mV/km and the current direction is shown to be at right angles to the nearby coast line. The diurnal variation of earth currents for both quiet days and disturbed days is given and the effect of the different seasons on the quiet day variation is also examined. Good agreement is found between the shape of the diurnal variation curve for earth currents and the diurnal variation of dZ/dt, the rate of change of the vertical component of the earth's magnetic field, and the anomalously large value of earth current amplitude is shown on comparison with data for other equatorial stations, to be related to the anomalously large daily range of Z which occurs near the equatorial electrojet.
A

HUTTON, Rosemary. The solar and lunar daily variations of earth currents near the magnetic equator. J. Atmos. Terrest. Phys. 24, 673-680 (1962).

The results of analyses of earth current measurements at two stations in Ghana, Legon (5° 38' N, 0° 11' W) and Tamale (9° 25' N, 0° 53' W), are discussed and it is suggested that in the equatorial region, the electrojet causes an enhancement of the solar daily variation of the earth currents by a factor of 6 or less. To account for the seasonal change in the S_q variation, it is suggested that there may be a seasonal shift in the mean position of the S_q current system and of the electrojet. The annual mean S_D hodograph was constructed and shows a marked deviation from its average behaviour at approximately 1800 hrs. An estimate of the magnitude of the lunar variation of the earth currents at Legon was also obtained from one year's data. It is approximately 12% of the solar daily variation.
PA

HUTTON, Rosemary. Equatorial micropulsations and ionospheric disturbance currents. Nature 195, 269-270 (1962).

The times of occurrence of regular geomagnetic pulsations, pc, of period 20−30 sec which has a maximum of occurrence in the evening at the equatorial station, Legon, Ghana and a midday maximum at mid-latitude stations have been correlated with the disturbance daily variation, S_d, of the earth currents. It is concluded that the most probable times of onset of geomagnetic activity of type pc coincide with the three daytime maxima of S_d, i.e., 6 hr, 12 hr and 18 hr. The night time maxima of S_d are found to correlate fairly well with the maxima of occurrence of pt pulsation activity.
MGA

HUTTON, Rosemary. The disturbance daily variation of the earth's field near the magnetic equator. J. Geophys. Res. 68, 2395-2402 (1963).

The S_D variations of the horizontal and vertical magnetic elements of the earth's magnetic field at nine mid- and low-latitude stations and of the earth-current components at Legon, Ghana, are presented and discussed. For stations in the region of the equatorial electrojet in Africa, the S_D variations differ considerably from those at midlatitudes. The difference between the equatorial S_D and the midlatitude S_D is found to consist of variations with a midday maximum in H and a midday minimum in Z. This finding suggests that there is either (a) an additional S_D current near the magnetic equator or (b) an increase in the strength and width of the equatorial electrojet during magnetic disturbance. Also the earth-current S_D variation is found to agree reasonably well with the derivative of the S_D variation of the total field F.
A

HUTTON, Rosemary. The S variation of earth currents near the magnetic equator, its seasonal changes, and its relation to variations of the magnetic field. J. Geophys. Res. 68, 2403-2410 (1963).

The harmonic coefficients of the earth-current variations at two stations in Ghana are presented and discussed. The ratio of the two principal harmonics of the variations at Legon are found to exhibit a seasonal variation, which is interpreted as arising from a shift in the position of the electrojet axis. Chapman and Whitehead's expressions relating earth-current variations with variations of the magnetic field are discussed, with reference to corresponding relations deduced by Tikhonov and Lipskaya.
A

IBRAHIM, Z. The abnormal variations of the horizontal magnetic intensity at Huancayo, Peru. Proc. Math. Phys. Soc. Egypt 1, 21-24 (1953).

In previous papers published in the journal, calculations were made of the ionospheric current systems which would arise from lunar atmospheric tidal motions as in the Stewart-Schuster dynamo theory taking into account (I) the obliquity of the earth's magnetic axis, (II) non-isotropic conductivity of the ionosphere as a result of the reduction of the conductivity of the ionized layers caused by the earth's magnetic field which was pointed out by Pedersen, and (III) the dependence of the conductivity on the sun's zenith distance by taking the electron density values from Millington's charts. The current functions were calculated for equinoxes in two cases, (I) when the sun and the moon are in the plane containing the geographic and the magnetic axes, and (II) when they are 90° east of that plane. In this paper the magnetic field of the derived current system is calculated at various points on the earth's surface and the daily variation of the horizontal component at Huancayo was found to be nearly twice in intensity as the daily variation at Batavia.
MGA

INGRAHAM, R. L. Note on the tidal theory of the S_q magnetic field. J. Atmos. Terrest. Phys. 16, 263-273 (1959).

The observed ratio of the diurnal to the semidiurnal components of the S_q field is greater than unity, although one would expect a ratio about a thousand times smaller on order of magnitude tidal theory. We therefore have made an exact calculation using a dynamo theory, with a certain analytically manageable model of diurnal and semidiurnal tides derived from the linearized Taylor-Pekeris theory to see whether "accidental" features might arise. It is shown that the anomaly persists. Possible explanations of the puzzle based on the details of this tidal theory are suggested. (1) There may be a resonating diurnal mode besides the well-established semidiurnal one. (2) Diurnal and semidiurnal motions rise to high maxima around latitudes 30°N and S and in the polar regions, respectively, as a result of the rotation of the atmosphere. This feature is ignored in both order of magnitude theory and in our model. The diurnal maxima should have much greater weight than the semidiurnal in the integral for the S_q field.
A

IGY, U. S. National Committee for. Magnetograms and hourly values - Guam, Mariana Islands. Rept. MHV - Gu 58, 1, U. S. Department of Commerce, Coast and Geodetic Survey (1960).

This report is the first of a series presenting the records of the Guam Magnetic Observatory in the form of quarter-size reproductions of the magnetograms and tables of hourly mean values of each of the magnetic elements — declination (D), horizontal intensity (H), and vertical intensity (Z).

The hourly values were processed by punched-card methods in the Washington Office of the Coast and Geodetic Survey.

The Guam Magnetic Observatory was established in July 1957 as a part of the International Geophysical Year program. It was one of twenty magnetic observatories constructed especially for the IGY and operated by the Survey in the United States (including Alaska), Oceania, and Antarctica. Instrumentation was provided by the Coast and Geodetic Survey for ten others in the Pacific, in South America, and in the Arctic and Antarctic, the stations being operated by other institutions.

The initial consideration by the U. S. National Committee, IGY, in the establishment of the Guam observatory was to provide a comparative basis for study of the "equatorial electrojet" effect as revealed by the magnetic records at Koror Magnetic Observatory, near the dip equator and some 1300 km (800 miles) southwest of Guam. The importance of its continued existence being recognized, Guam observatory is still (1960) in operation. It provides data valuable in following the east-west effect of magnetic secular change phenomena, in the more accurate charting of the earth's magnetic field in this region, and in the study of transient phenomena in equatorial regions.

The net of permanent magnetic observatories operated by the Coast and Geodetic Survey extends to almost 150° in longitude. The Survey now regularly operates eight observatories, the other seven being located at Fredericksburg, Virginia; Honolulu, Hawaii; San Juan, Puerto Rico; Tucson, Arizona; Barrow, College, and Sitka, Alaska. In addition, two Antarctic observatories, constructed for IGY, are being continued by the Survey under the U. S. Antarctic Research Program. These are at Byrd Station and the South Pole.

A

IGY, U. S. National Committee for. Magnetograms and hourly values - Koror, Palau Islands. Rept. MHV-Kr 58, 1, U. S. Department of Commerce, Coast and Geodetic Survey (1960).

Scientists in geomagnetic research have for some years been interested in obtaining information on the magnetic variations near the magnetic equator in the Pacific Ocean area. When the U. S. National Committee first began planning its program for the International Geophysical Year, it

was decided to establish a station at Jarvis Island, which lies near the intersection of the geographic and magnetic equators. Later, owing to increased interest in magnetic equatorial stations for studies of the "equatorial electrojet," the Committee decided to establish another such station in the Pacific. Koror, an island in the Palau group of the Western Caroline Islands, was selected for logistic and scientific reasons. As it turned out, the choice was excellent, the magnetic dip alternating between north and south values on many days. The Guam Magnetic Observatory, also established as part of the IGY program, is less than ten degrees distant from Koror, providing an opportunity for comparison of data in regard to the electrojet effect.

From 1926 to 1941 the Japanese Hydrographic Office conducted magnetic observations in a special nonmagnetic structure near their weather station on Koror. It is understood that only declination observations were made and the annual mean values have been published. All original records are believed to have been destroyed by fire during World War II. This earlier site was found by the Coast and Geodetic Survey, but the site is now artificially disturbed. Determination of the station difference was therefore impossible.

A

INTERNATIONAL SYMPOSIUM ON EQUATORIAL AERONOMY. J. Geophys. Res. 68, 2359-2611 (1963).

The Symposium was held near Huancayo, Peru, from 18 to 25 September 1962. Sixty people from 18 countries attended, and the scientific sessions were arranged into 9 groups as follows: (1) The regular equatorial D and E regions, absorption in the D, E and F regions, D- and E-region airglow. (2) The equatorial electrojet; theory and observations, including inferences from magnetic and earth-current studies, lunar effects, longitudinal and latitudinal variations. (3) Irregularities in the equatorial electrojet. (4) The equatorial F-region electron-density distribution. (5) Airglow in the equatorial F-region. (6) Theory of the equatorial F-region; photochemistry, diffusion, electrodynamics. (7) Irregularities in the equatorial F-region; inferences from spread F and satellite radio signals. (8) Theories of the origin of F-region irregularities. (9) The equatorial exosphere; cosmic-ray effects in the equatorial ionosphere, magnetic storm effects, solar – terrestrial relations, synchroton radiation, effects of nuclear explosions.

PA

INTERNATIONAL SYMPOSIUM ON FLUID MECHANICS IN IONOSPHERE.

J. Geophys. Res. 64, 2037-2238 (1959).

Excerpt

IRELAND, W., and J. Mawdsley. Radio echoes from field-aligned ionization at the magnetic equator. J. Geophys. Res. 67, 2583-2585 (1962).

Ionization giving rise to radar auroral echoes is field-aligned (Unwin, 1958) and appears to be associated with the intense S_D component of the electric current flowing in the auroral ionosphere at times of magnetic disturbance (Unwin, 1959). In view of this apparent association, Unwin (private communication, 1958) suggested that an ionospheric echoing region of field-aligned ionization might be a permanent daytime feature near the magnetic equator, in association with the equatorial electrojet. The opportunity for us to test Unwin's suggestion occurred only recently.

Bowles, Cohen, Ochs, and Balsley (1960) and Egan (1960) have already reported echoes from field-aligned ionization in the E region at Huancayo on the magnetic equator at several radio frequencies up to 50 Mc/s. These echoes occur only during the day and are thought to be closely associated with the equatorial electrojet. According to Bowles and co-workers the echoing region is about 7 km thick, and its center is between 100 and 105 km above sea level; the echoes resemble, in several features, those observed at auroral latitudes. The purpose of this note is to report observations of similar echoes at a frequency almost double any previously reported, using a radar operating in the 3-meter band on board HMNZS Royalist in the vicinity of Singapore.

Figure 1 summarizes part of the program carried out by Royalist. Observations were made daily between 0800 and 1600 hours local time, with the antenna bearing magnetic east and magnetic west respectively during successive half-hour intervals. Records were taken by moving a photographic film continuously past an intensity-modulated oscilloscope to give a range-versus-time record. Ionospheric echoes were observed only on June 20, 1961, the day the magnetic equator was crossed. They were

observed on both bearings, being present from about 1045 hours to 1445 hours, which, together with their absence on preceding and following days, suggests a close resemblance to the Huancayo observations. From the appearance of the slow-moving range-versus-time film, the signal-to-noise ratio, averaged over several seconds, probably did not exceed 10 db. Unless the echoes were unusually strong on June 20, they should normally be detectable by a moderately high power radar (500 kw, 15 μsec pulses) with a modest antenna (about 12 db gain) operating in the 3 meter band.

On the range-versus-time record the echoes, ranging from less than 200 to almost 600 km, displayed a clearly banded structure owing to the vertical plane radiation pattern of the elevated antenna. This pattern can be exploited to measure the height and thickness of the echoing region after the manner of Unwin and Gadsden (1957). In our observations no echoes were returned in the two lowest lobes because of inadequate sensitivity. Nevertheless, the separate range groups are readily identified with their corresponding lobes, since only one combination gives plausible results with the antenna pointing both east and west. This is shown in Figure 2. When the most distant echo is associated with the third lobe, the echoing region turns out to be effectively horizontal. If, instead, it is associated with the second or fourth lobe, respectively, the echoing region either falls or rises rather rapidly to either side of the radar. Figure 2 actually shows (for each range group) the average of eight estimates of the range to the center of the echoing region distributed evenly throughout the observing period (four when the antenna was bearing east, and four west). The average value for the height of the center of the echoing sheet is 111 km, individual values being spread over ± 2 km from this value. The estimated maximum error in determining the absolute height from a single observation of the echo in a particular range group is ± 4 km. Atmospheric refraction is neglected in Figure 2. (It would drop the average height for the most distant echo from approximately 1 km above to 1 km below the average for the whole sheet, the effect becoming less at shorter ranges.) The spread in range of individual echoes indicates that the echoing region was never more than about 10 km thick.

The present observations support the idea that the echoing region is associated with the electrojet. Both are daytime phenomena at about the same altitude, and are confined in latitude to a relatively narrow zone at the magnetic equator. There is a suggestion that the echoing region may be higher near Singapore than Huancayo. Rocket magnetometer observations of the electrojet suggest a similar trend, and, indeed, it may be that the center of the echoing region is to be identified with the height at which the electrojet current is a maximum. An early rocket flight near Huancayo (Singer, Maple, and Bowen, 1951) failed to penetrate the current sheet completely, but according to Singer (1954) it was unlikely to extend much above 105 km. Therefore, the maximum probably lay between 100 and 105 km, close to the center of the echoing region measured by Bowles,

Cohen, Ochs, and Balsley (1960). In more recent flights Cahill (1959) observed an electrojet current maximum over the central Pacific Ocean at a height of about 105 km. However, it is important to remember that the separate observations were made at considerably different times, and that the radio observations were made at different frequencies — in our work on only one day.
Excerpt

ISTED, G. A. Irregularities in the E region caused by atmospheric electricity. Physics of the Ionosphere, 150-162 (The Physical Society, London, 1955).

It has been demonstrated that single-hop communication over distances up to 1500 km, on radio frequencies between 30 and 60 Mc/s, is practicable when use is made of the irregularities existing in the E region. Many of these irregularities give rise to sporadic echoes of short duration which may be detected at vertical incidence when the E-region is illuminated by radio frequencies ranging from about 5 to 100 Mc/s. Some of these echoes are undoubtedly due to ionization caused by meteors, but recent experimental evidence suggests that the majority observed on the lower frequencies are due to weather clouds discharging upwards to the E-region where ionization is produced above the cloud. These upwardly directed weather cloud discharges do not necessarily involve lightning between ground and cloud but the change in the electric field may be detected at great distances in the form of an "atmospheric." This type of atmospheric can be distinguished from the type caused by lightning, and radio directional measurements show that the greatest concentrations of both types emanate from the great equatorial land masses illuminated in turn by the sun. Because these world-wide upward cloud discharges maintain the E-region at a high potential, the vertical field of which is found in areas of clear sky, they exercise a rigid control over the ability of a local cloud to discharge, and a close relationship therefore exists between the diurnal variation in the number of world-wide discharges and the number of E-region sporadic echoes.
A

PREVIOUS PAGE WAS BLANK, THEREFORE NOT FILMED

JACKSON, J. E., and S. J. Bauer. Rocket measurement of a daytime electron density profile up to 620 kilometers. J. Geophys. Res. 66, 3125-3140 (1961).

The electron density profile over the height range 225-620 km, determined by the c.w. Doppler technique using a four-stage rocket launched from Wallops Island on 27 April 1961, gives an F2 peak density which is in excellent agreement with the vertical soundings data obtained at the same time, and a practically constant logarithmic slope above. This is representative of diffusive equilibrium in an isothermal atmosphere at 1640°K, and suggests that there is thermodynamic equilibrium in the upper atmosphere.
A

JACOBS, J. A., and K. Sinno. Occurrence frequency of geomagnetic micropulsations. J. Geophys. Res. 65, 107-113 (Jan. 1960).

An analysis of the occurrence frequency of geomagnetic micropulsations Pc has been carried out using data obtained during the IGY from a world-wide network of stations. From the characteristics of the diurnal occurrence frequency and their latitudinal and longitudinal dependence, the following conclusions are drawn: (1) The occurrence frequency of Pc's increases as the auroral zones are approached from lower latitudes. Also the hour of the diurnal maximum occurrence appears earlier at high-latitude stations. (2) The occurrence frequency of Pc's depends not only on local time but also in part on universal time. The universal-time factor affects the modulation of the diurnal occurrence by about 50 per cent. The time of maximum occurrence of Pc's is about 21 hours GMT in the northern hemisphere. In the southern hemisphere the universal-time factor has opposite phase to that in the northern hemisphere. When the universal-time factor is a maximum in the northern (or southern) hemisphere, the north (or south) geomagnetic pole is about 16 or 17 hours LMT. The GMT dependence derived in this investigation shows about 7 hours' difference compared with Troitskaya's conclusion, which was based on data from several stations in the USSR.
A

JACOBS, J. A., and T. Watanabe. The equatorial enhancement of sudden commencements of geomagnetic storms. J. Atmos. Terrest. Phys. 25, 267-279 (1963).

A tentative theory is proposed for the well known enhancement of sudden commencements of geomagnetic storms near the magnetic equator. The principal idea is that the equatorial electrojet which has been invoked to explain the large amplitude of the quiet day daily variation in the (magnetic) equatorial regions is enhanced at the time of a sudden commencement (sc) of a geomagnetic storm. The westward electric field which is associated with the sc-variation of the geomagnetic field causes a downward movement of charged particles in the ionosphere which accumulate in the lower regions of the ionosphere. This yields an increase in the ionospheric electrical conductivity and accordingly in the intensity of the electrojet.

A

JASIK, H., ed. Antenna Engineering Handbook. (McGraw Hill Publishing Co., Inc., New York, 1961).

The "Antenna Engineering Handbook" is intended to serve as a compendium of antenna design data and principles. Although it is expected that it will prove most useful to the engineer who is actively engaged in designing antennas, it will also be of considerable use to the electronic systems engineer who desires to understand the capabilities and limitations of the antenna as a component. The treatment is at the engineering level and is directed toward an understanding of antenna problems in addition to presenting an extensive collection of design data. Within its scope, it is believed that this handbook represents the most comprehensive treatment of the antenna art which has appeared in book form to date.

To keep the size of the Handbook within reasonable bounds, it has been necessary to select for presentation only those areas which are of greatest current importance to the antenna engineer and designer. Accordingly, the major part of the coverage is given to antenna types and structures that have found extensive use in practice or that have a large potential for such use. Theoretical discussions and mathematical formulations are given only where essential to understanding. Wherever possible, results have been presented in graphical or tabular form.

The Handbook is organized into four major groups of chapters, as follows:

I. Introduction and Fundamentals

II. Antenna Types and Methods
III. Applications
IV. Topics Associated with Antennas

Excerpt

JOHNSON, F. S. Pressure and temperature equalization at 200-km altitude. J. Geophys. Res. 65, 2227-2232 (1960).

Atmospheric pressure at 200 km must be nearly constant over the entire earth as a result of large-scale air motions which can occur in the ionosphere. In the lower atmosphere, adjacent areas of high and low pressure can exist without annhilation by pressure equalization; direct air flow from high to low pressure does not occur, because balanced circulations develop in which inertial forces (centrifugal and Coriolis) balance the pressure forces and prevent equalization. At altitudes near 200 km, viscous forces prevent the balanced circulations from occurring, so pressure equalization can proceed rapidly. The heat transport associated with the air motion is large and tends to bring about temperature equalization also. At still higher altitudes, the heat content and the pressure forces are smaller but the viscous forces for a given velocity shear remain unchanged, making possible the existence of pronounced high-pressure areas in regions of local heating. The conclusion reached in this study does not permit one to accept the frequently held concept that the polar or auroral zone ionosphere is much warmer than the equatorial ionosphere with pressures at 200 km several times larger in the polar regions (e.g., at Churchill, Canada) than at temperate and low altitudes (e.g., at White Sands, New Mexico).
PA

JOHNSON, M. H. Symposium on Dynamic Characteristics of the Ionosphere, IN: Proc. Conference on Ionospheric Physics, State College, Pa., 24-27 July 1960, (see also comments by D. F. Martyn, and A. G. McNish).

One point seems to me to indicate that diffusion in the F layer is highly probable and that is simply the law of gravity. If you take a molecular density of 10^{10}, then your diffusion rate of ions under the force of gravity must be in the neighborhood of several km. an hour. This would indicate

to me that as soon as density gets as low as 10^{10} (Ferraro pointed this out a long time ago) then there will be substantial effects of diffusion. Now if you rely on the rocket measurements, it appears that the densities already at 150 km are perhaps 4 or 5 times 10^{10}. This is certainly a good reason for being very suspicious that there should be some effects of diffusion at 250 or 300 km. So I just want to add that one argument for diffusion.

I would like to discuss one other simple problem. Supposing that you have a uniform wind, the air is moving with constant velocity everywhere, you have some positive and negative ions constituting a neutral gas in the air, and it moves any direction you wish with respect to the magnetic field, then it would appear to me that we could certainly look at this from a reference plane on which the air is still. In this case we will still see essentially the same magnetic field and the only difference will be that we will see an electric field according to the well-known formula $U \times \frac{H}{C}$. Now you pointed out that for a neutral cloud of ions in an electric field the electric field has practically no effect. It just polarizes the cloud. So I would like to make this simple case a starting point of any discussion of what the magnetic field does to the relative motion of the ions with respect to the medium, because it seems to me that in this simple case there is no effect of the magnetic field on the motion of the ions with respect to the air. Moreover, if you want to say there is some effect of the magnetic field on the motion of the ions with respect to the air, this must be connected with the velocity gradient in the gas. Therefore in speaking of this problem one should really show how it is that the magnetic field can bring about a motion with respect to this gas, because in this simple case it seems to me clear that there is no such motion.

Excerpt

JOHNSTON, H. F., and A. G. McNish. Variations of the earth's magnetic field at the observatories of Watheroo and Huancayo. Compt. Rend. 12, 41-52 (1932). (In French.)

No abstract available.

JOHNSTON, H. F., A. G. McNish, S. E. Forbush, W. E. Scott, Ella Balsam, and P. G. Ledig. Magnetic results from Huancayo Observatory, Peru, 1922-1935. Publication 175, 1, Carnegie Institution of Washington (1948).

The Huancayo Magnetic Observatory is situated in latitude 12° 02'.7 south and longitude 75° 20'.4 west, at an elevation of about 11,000 feet (3350 meters) above sea level. A brief history of the search for a suitable

J

site is given in the following paragraphs, as well as a description of the site finally chosen, the observatory buildings and instruments, and the methods of observation. A discussion of treatment of data follows the descriptive material.
A

JULL, G. W., and G. W. E. Pettersen. HF non-reciprocity and polarization fading. Paper presented to Commission III of URSI, Fall Meeting, Ottawa, Canada, 17 Oct. 1962.

Studies have been carried out to elucidate the source of non-reciprocal fading of HF signals over oblique incidence paths. Two-way pulse transmissions were carried out between matched transmitters, receivers and antennas situated at each end of the east-west Ottawa-Halifax path (960 km). Pulses of 25 μsec width were synchronously transmitted from each end to arrive at the path midpoint within a small fraction of a fading period. Through the use of orthogonal antennas, it was established that polarization fading was often the predominant type of deep short-term fading for single-hop F-layer transmissions during the day. During these periods of predominant polarization fading, the fading of signals received at each end on matched horizontal rhombic antennas were inversely correlated. The signal maximum at one terminal was displaced in time from the maximum at the other terminal by the order of one-half a fading period.

By way of contrast, for received signals not exhibiting appreciable polarization fading (via either F- or E-layer) the random fading observed simultaneously at each terminal was directly correlated.

It is concluded that while polarization fading on east-west paths is not an exclusive source of non-reciprocal fading, it is very important. Preliminary observations indicate that non-reciprocal polarization fading will be observed on east-west paths under conditions for which the energy of received ordinary and extraordinary rays are comparable and the duration of signals exceeds the time separation of the magneto-ionic components.
A

KALININ, Yu. D. Magnetic and ionospheric disturbances. Collected articles pertaining to Sections III and IV of the IGY Program (Geomagnetism and Earth Currents, Ionosphere). Translation of compilation made under the auspices of the Interdepartmental Committee for the conduct of the IGY under the Presidium of the Academy of Sciences of the USSR, 1959. (1961). AD-249 291. Also NASA Tech. Trans. TT F-49.

Abstract not available.

KAMIYAMA, H. The distribution of the ionospheric disturbances during the geomagnetic bay. Rept. Ionosphere Res. Japan 7, 70-71 (1953).

Using ionospheric data from 35 stations to analyze the distribution of the deviation in foF_2 during the geomagnetic bay, the author found that at comparatively high altitude electric density increased in the afternoon but decreased considerably at sunset. In the middle latitudes the semi-diurnal system of deviations is noticeable. At low latitude, near the magnetic equator, the negative deviations occur in the afternoon in contrast to the stations at high latitudes. The percentage deviations are calculated by means of a diagram.
MGA

KAMIYAMA, H., and T. Sato. The latitudinal effect on the disturbance daily variation in F2 layer of the ionosphere. Sci. Rept. Tohoku University 8, 41-51 (1956).

Studied solar disturbance variation in maximum electron density of F layer. Find amplitude controlled by geomagnetic latitude and phase by geographic latitude. In equinoctial months harmonic coefficients almost symmetrical about equator; in solsticial months axes of symmetry move toward winter hemisphere. Give equal-deviation charts for different seasons. Tabulate mean harmonic coefficients for each season and plot results.
M

KAMIYAMA, H. The spiral distribution of the sporadic E ionization in the polar region. Rept. Ionosphere Space Res. Japan 16, 415-419 (Dec. 1962).

Analyses of IGY and IGC data from a number of ionospheric stations widely distributed over the northern hemisphere show that the sporadic E

ionization in the polar regions has a spiral distribution. This conclusion can be reached both from a statistical study and from the analysis of individual cases.
PA

KAZIMIROVSKIY, E. S. The latitude variation of the midday directions of horizontal drift in the lower ionosphere. Geomag. Aeron. III, 578-579 (1963). (Original in Russian).

The literature covering investigation of the horizontal drift of inhomogeneities in the ionosphere contains repeated statements that there should be a geomagnetic control of the drift parameters. Data for 15 stations in the northern hemisphere were used to compute the mean value φ (λm) at local midday from measurements during the three summer months — June, July and August. It can be established for the summer season that the midday direction of drift changes linearly with geomagnetic latitude. It had previously been established that there was a linear dependence φ (λm) during the winter (φ is the direction of drift in degrees, read clockwise from north, λ m is geomagnetic latitude). Until now no data have been available to confirm this relationship for the summer season.
A

KAZUO, Y. Disturbance daily variation of the earth-currents at Kakioka. Mem. Kakioka Mag. Observ. 7, 49-54 (1954).

The daily variation on quiet days, Sq, of the earth-currents at Kakioka for a 11-year period, 1934-1944, were formerly summarized in the Report of the Kakioka Magnetic Observatory. In the present paper, some characteristics of the disturbance daily variation, S_D, of the earth-currents for the same period are given, as follows: —

i) In the mean values S_D and S_A = S-Sq computed for the whole period, there is remarkable secondary minimum at 10^h (Fig. 1). The two values are coincident each other in phase, but the amplitude of the latter is about 40% of the former.

ii) The change of the amplitude of S_A (or S_D) with seasons and years is remarkable in the diurnal component, but not clear in the semi-diurnal component (Figs. 2 and 4). The appearance of a secondary minimum at

10^h may be uncertain at equinox and sunspot-maximum year, because of the predominant diurnal component in the same period.

iii) Our result in (i) differs from the well-known conclusion that the S_D in earth-currents is materially a single wave (diurnal one) as in earth-magnetism. Then, the mean S_A at Tucson for the period 1932-1942 is computed (Fig. 3). As it is seen in the figure, especially in the vector diagram, departures from the diurnal variation in the hours 12^h - 18^h and 3^h-7^h are remarkable. Again, the result at Watheroo (after Rooney) shows some departures from diurnal variation.

Generally speaking, the appearance of the secondary minimum is not a local phenomenon at Kakioka, but seems to be of world-wide character. It may be related to the disturbances of short period or duration.

Excerpt

KELLEY, L. C. Long-term predictions of maximum usable frequencies for sky-wave radio communications. Tech. Rept. 8, U. S. Army Signal Radio Propagation Agency, Fort Monmouth, N. J. (March 1955).

This report presents a method of forecasting years in advance the upper limits of the spectrum space that would be available from the wave propagation standpoint for long distance sky-wave radio communication in the high frequency band, ordinarily 2 Mc to 30 Mc. Observations, made over a long period of time, show a correlation between the critical frequencies (highest frequencies reflected by the ionosphere at vertical incidence) and solar activity, quantitatively represented for the purposes of this report in terms of "sunspot number." The "sunspot number" is a number based on daily observations of the spots on the solar disc. The variations of the monthly and yearly means formed from the daily counts of the sunspots are cyclic; the period from minimum to minimum of a sunspot cycle is variable, but it averages around 11 years. The frequencies useful for radio communication at oblique incidence (i.e., at any distance) for any particular year, season and month, are functions of critical frequencies at particular points along the transmission path. Consequently, utilizing the observed correlation between critical frequencies and sunspot numbers, frequency-charts can be prepared corresponding to any sunspot number, or high and low sunspot numbers indicative of the range of upper limiting frequencies throughout the period of the sunspot cycle. The problem of frequency prediction for any particular month and year is thereby reduced to that of forecasting sunspot numbers for the desired month and year.

Though short range frequency forecasts are available in TB 11-499,

three months in advance of the applicable date, there exists a need for long-term predictions in several practical applications of radio communication, especially in the advance planning and system design of sky-wave communication circuits. A knowledge of the probable range of frequencies required for satisfactory operation throughout the years of the sunspot cycle, aids in the frequency allocation problem, the proper selection of equipments and their maximum utilization, the location of sites, etc. Used in conjunction with reference 10, the charts of this report enable the range of transmission and reception angles most likely to effect satisfactory communication throughout the period to be predicted. This information may form a basis for the design of new equipment for efficient utilization of the propagation media. These predictions aid in the evaluation of future frequency allocation requirements of existing circuits, and in the determination of the adequacy of frequency complements, but above all they facilitate the integration of the wave propagation aspects in the over-all system design of communication circuits.
Excerpt

KELLEY, L. C., and A. A. Silva. Revised radio noise data. Project 700, U. S. Army Signal Radio Propagation Agency, Fort Monmouth, N. J. (March 1960).

The report presents new signal level requirements for radiotelephone communication in the presence of external radio noise. As an interim measure, it provides the latest available data pending a complete revision of U. S. Army Signal Radio Propagation Agency Technical Report Nr 5, "Minimum Required Field Intensities for Intelligible Reception of Radiotelephony in Presence of Atmospheric or Receiving Set Noise". No copies of Technical Report Nr. 5 will be available until the revision is completed about January 1961. Holders of previous versions are advised to use this report for computing required signal levels in the presence of atmospheric, galactic, and man-made noise. Directions for computing the LUF (the lower limiting frequency that provides communication for 90 per cent of the days of the month) in U. S. Army Signal Radio Propagation Agency Technical Report Nr. 6, "Calculation of Sky-Wave Field Intensities, Maximum Usable Frequencies and Lowest Useful High Frequencies", contain references to atmospheric noise curves of Technical Report Nr. 5. Although the presentation of data in this report is different, the information can be used in the same way. An explanation of the new charts appears below.
Excerpt

KENDALL, P. C., and J. E. C. Gliddon. Geomagnetic control of diffusion in the F_2 region of the ionosphere. I. The form of the diffusion operator. Tech. Note, Queen Mary College, London University (27 March 1962).

The mathematical form of the diffusion operator is derived for motion of electrons along the lines of force of a dipole approximation to the geomagnetic field. The earth's atmosphere is assumed to be isothermal and horizontally stratified. A table is given of the various forms of the diffusion operator in different independent coordinates. The results are applied briefly to a discussion of the form of the boundary condition at great height in the F_2 region.
STAR

KENDALL, P. C. Geomagnetic control of diffusion in the F_2 region of the ionosphere. 2. Numerical results. Tech. Note. Queen Mary College, London University (25 Oct. 1962).

The equation governing electron diffusion in the F_2 region along the lines-of-force of a geocentric magnetic dipole, whose axis coincides with the earth's, is solved numerically in the equilibrium case when there is electron production, loss by recombination, but no transport of electrons by electrodynamic drift. The results show that for the parameter values considered, the extra terms in the diffusion equation, caused by the variation of the gravity component along a line-of-force, lead to only a slight dip in N_{max} at the equator. The dip is much too small to explain the Appleton anomoly in terms of diffusion alone.
STAR

KENRICK, G. W., A. M. Braaten, and J. General. The relation between radio-transmission path and magnetic-storm effects. Proc. IRE 26, 831-847 (1938).

This paper presents the results of a quantitative study of the relationship between the proximity of great-circle transmission paths to the magnetic pole and of signal stability during terrestrial magnetic disturbances. Reception from Europe as observed at Riverhead, Long Island, and San Juan, Puerto Rico, is compared during normal and disturbed periods. The great-circle path from Europe to San Juan is about 1000 miles farther from the north magnetic pole than a similar path to Riverhead.

A brief description of the duplicate equipment and antenna systems employed at the two locations is included.

It has been known for some time that the more southerly transmission paths are apparently less susceptible to effects accompanying magnetic disturbances. The results of observations covering a period of years confirm the anticipated relationship between signal stability and proximity of the transmission path to the magnetic pole. The average advantage of San Juan over Riverhead for European signals during disturbed periods is found to be approximately 8 decibels.

Evidence of higher ionospheric ionization over the more southerly path is noted in a number of cases by a comparison of nighttime cutoff effects and allied phenomena.

A

KENT, G. S. High frequency fading of the 108 Mc/s wave radiated from an artificial earth satellite as observed at an equatorial station. J. Atmos. Terrest. Phys. 22, 255-269 (1961).

A study was made of the high frequency fading observed on the 108 Mc/s wave radiated from satellite 1959η . This fading had a frequency of a few cycles per second and is believed to be caused by the passage of the waves through irregularities in the F-region of the ionosphere. These irregularities are found to occur only at night and to have a dependence upon magnetic activity and latitude similar to that found for spread-F irregularities. In addition they are found to have a tendency to be concentrated into regions with dimensions of the order of 100 km. The size and shape of the irregularities were deduced from observations on the fading and from spaced aerial measurements. They are elongated along the magnetic lines of force with axial ratios of not less than 5 : 1 and have dimensions perpendicular to the lines of force of about half a kilometre.

PA

KENT, G. S., and J. R. Koster. Height of night time F layer irregularities at the equator. Nature 191, 1083-1084 (1961).

Work in progress at Ibadan indicates that the irregularities in the pattern on the ground as deduced by a study of satellite and radio-star transmissions through the disturbed region show an elongation in the direction of the earth's magnetic field. The heights of the irregularities have been determined by observing, at two different stations, the diffraction pattern produced at the ground when the radio transmissions from an earth satellite

pass through the irregularities. The velocity of the pattern over the ground is then related to the known height and velocity of the satellite. The height of the diffracting screen can then be determined. Observations using Tiros II during June and July, 1961 are reported. The effective height of all the observed irregularities always lay between 50 km and 100 km above the base of the F layer.
MGA

KENT, G. S., B. R. Clemesha, J. R. Koster, and R. W. H. Wright. Equatorial study of irregularities in the ionosphere. Annual Summ. Rept. 2, Ghana University, Africa (1 March 1963).

This report describes a number of experiments which were designed to investigate F-region irregularities by means of the back-scatter technique. The experimental techniques are described briefly, and the results given in detail. The results show the seasonal and nocturnal variations in the occurrence of irregularities which scatter 18 mc/s signals, the size and drift velocity of patches of irregularities, the height at which the irregularities occur, and the motion of the irregularities, as opposed to the motion of the patch. The results are discussed in the light of information obtained by other workers using different techniques.
STAR

KERBLAI, T. S. On the dependence of top frequencies of the sporadic Es layer on the ionosonde system gain. Akad. Nauk SSSR. Mezhduvedomstvennyi Komitet po Provedeniiu MGG, Sbornik Statei V Razdel Programmy MGG (Ionosfera) 5, 50-63 (1960). (In Russian; English summary p. 63.)

The dependence of f_0Es on the equipment characteristics (transmitter power, antenna gain, receiver gain) is determined according to the variations of the reflection coefficient ρEs with frequency. The type function $\rho Es(f)$ determines a degree of variation fEs with the change of equipment characteristics. The paper considers types of the function $\rho Es(f)$ for several models of the layer, and for each of these, dependence on equipment is estimated. Experimental data on the variations ρEs with frequency for different types of Es are obtained by the analysis of the differences ($f_0Es - f_bEs$) for the 8 IGY stations. The comparison of the experimental data with theoretical calculations makes it possible to establish correlation between different types of Es and the models considered. Ionograms with different gain, which rendered information on the character of fEs variation

with the change of gain which on the whole agrees with the conclusions drawn from the analysis of differences ($f_0Es - f_6Es$). It is concluded that the highest dependence on the equipment is observed for high-altitude types of Es, except the γ type, and for the equatorial types. For the middle latitudes, as a rule, all types of Es depend very little on the equipment.
MGA

KERN, J. W. Geomagnetic field distortion by a solar stream as a mechanism for the production of polar aurora and electrojets. Res. Memo. 2753, Rand Corp., Santa Monica, Calif. (26 May 1961).

This paper describes a mechanism for charge separation in the geomagnetically trapped radiation which may account for some observed phenomena associated with the polar aurora and the electrojet current systems. The following development is proposed: given that there exist eastward or westward longitudinal gradients in the geomagnetic field resulting from distortion of the geomagnetic field by solar streams, if the trapped radiation is adiabatic in character, radial drift separation of positive and negative charged particles must occur. It follows that, for bounded or irregular distributions of plasma number density in such an adiabatic drift region, electric fields will arise. The origin of such electric fields will not arrest the drift separation of the charged particles, but will contribute to exponential growth of irregularities in the trapped plasma density. An adiabatic acceleration mechanism is described, which is based on incorporating the electrostatic energy of the particle in the energy function for the particle. Direct consequences of polarization of the geomagnetically trapped radiation will be the polar electrojet current systems and the polar aurora.
MGA

KERN, J. W. Solar-stream distortion of the geomagnetic field and polar electrojets. J. Geophys. Res. 66, 1290-1292 (1961).

Distortion of the geomagnetic field by an ionized solar stream has often been thought to be related to the occurrence of polar electrojet current systems and aurora (Chapman and Bartels, 1951; and others). Such distortion has been considered by Chapman and Ferraro (1931), Chapman (1960), and Ferraro (1960), Martyn (1951), and more recently by Piddington (1959, 1960), who considers the effects of the plasma content of the earth's exosphere, and suggests the possibility of a geomagnetic tail due to interaction with a solar stream. Distension of the geomagnetic field due to trapped particle currents (Dessler and Parker, 1959; Akasofu, 1960) may also

contribute to such distortion. Chapman (1950) formulated an experiment to clarify the physical effects that involved motion of an ionized gas past a magnet, but scaling difficulties prevented such an approach. Johnson (1960) has considered the over-all problems, introducing recent developments in plasma physics. If simultaneous day-side compression and night-side stretching of geomagnetic field lines is considered, the night-side stretching may be limited by the dynamic pressure of the solar stream (Martyn, 1951).

It is the purpose of this letter to point out that magnetic field gradients perpendicular to meridional planes may be introduced by such distortion with the creation of polar electrojets. It is claimed that longitudinal magnetic field gradients will lead to drift separation of geomagnetically trapped protons and electrons normal to field lines and in meridional planes, and thus to a suitable latitudinal charge separation in trapped radiation incident at auroral latitudes. Penetration of such polarized trapped radiation to the E region of the atmosphere is supposed to lead to electrojet current systems of the form observed. The work here continues the study of the concepts recently considered by Vestine (1960) and by Chamberlain, Kern, and Vestine (1960).
Excerpt

KERN, J. W. A charge separation mechanism for the production of polar auroras and electrojets. J. Geophys. Res. 67, 2649-2664 (1962).

A mechanism for charge separation in the geomagnetically trapped radiation is described that may account for some observed phenomena associated with polar auroras and electrojet current systems. Surfaces of constant number density may be separated from surfaces of constant integral invariant within the trapped radiation as a result of distortion of the geomagnetic field by solar streams. Drift separation of protons and electrons will follow, and, for irregular distributions of plasma number density, electric fields will arise. A direct consequence of such polarization of the geomagnetically trapped radiation will be the polar-electrojet current systems. The polar auroras arise where energetic particles are discharged from regions of excess charge within the geomagnetically trapped radiation. A model for the discharge of such auroral particles is discussed. An interesting feature of the proposed mechanism is that the extreme thinness of auroral sheets appears to follow as the natural consequence of charge separation. This is shown analytically for a simple two-dimensional model of a trapped plasma.
A

KERN, J. W. Solar-stream distortion of the geomagnetic field as a mechanism for producing polar auroras and electrojets. J. Phys. Soc. Japan 17, Suppl. A-I, 165-168 (1962).

A mechanism for charge separation in the geomagnetically trapped radiation is described which may account for some observed phenomena associated with the polar aurora and the electrojet current systems. Separation of surfaces of constant number density and surfaces of constant integral invariant may occur within the trapped radiation as a result of distortion of the geomagnetic field by solar streams. Drift separation of protons and electrons follows, and for irregular distributions of plasma number density, electric fields arise. A direct consequence of such polarization of the geomagnetically trapped radiation are the polar-electrojet current systems. The polar aurorae arise when energetic particles are discharged from regions of excess charge within the geomagnetically trapped radiation. A model for the discharge of such auroral particles is briefly discussed.
PA

KHASTGIR, S. R., and A. K. Ray. Intensity variations of the down-coming wireless waves from the ionosphere. Indian J. Phys. 14, 283-293 (1940).

Experiments with an aerial system for suppressing the ground-wave are described. After having suppressed the ground-wave the variations of the intensity of the down-coming wireless waves were studied. Typical continuous records of the variations of the intensity of such waves are presented. It is shown that the time variation of the amplitude of the down-coming waves is consistent with Rayleigh's formula for random scattering. The amplitude variation can therefore be explained as due to the interference of waves scattered from a series of diffracting centres at the ionosphere. The most probable value of the amplitude of the down-coming wave, as obtained from the experimental data on the intensity variations of the same wave, was compared with the amplitude of the ground-wave. Between Dacca and Calcutta the ratio of the vertical electrical forces produced by the ground-wave and the down-coming wave is estimated.
A

KHASTGIR, S. R., and M. Kameswar Rao. Some studies in high-frequency atmospheric noise at Dacca by the warbler method. Proc. IRE 28, 511-513 (1940).

In this investigation the warbler method was followed in measuring the atmospheric noise at Dacca during the month of June within the range of frequencies from 250 to 1500 kilocycles. Attention was directed to (1) the study of high-frequency atmospheric noise (both day and night) as a function of frequency, and (2) the study of the diurnal characteristics of high-frequency atmospheric noise with special reference to the sunrise and sunset times.
A

KHASTGIR, S. R., and M. I. Ali. Investigations on atmospherics in high frequency channels. Indian J. Phys. 16, 399-419 (1942).

The results of investigations on atmospherics carried out at Dacca during the monsoon time of 1940 on a range of frequencies from 2 Mc. to 20 Mc. are given in this paper. The peak method of measurements was employed and experiments were carried out along the following lines:

I. Determinations of the numbers of atmospherics from different directions in different frequency channels at different times of the day, with special reference to the sunrise and the sunset periods.

II. Measurements of the field-strengths of the atmospherics from the east-west direction (and occasionally from the north-south) in different frequency channels at different times of the day with special reference to the sunrise and the sunset periods.

Usually one and occasionally two maxima, some minutes before the ground sunrise were observed in both sets of experiments. Soon after the maximum, the field-strength and also the number decreased very rapidly and continued diminishing till some time after the sunrise. There was a subsequent rise indicating a maximum an hour or two after the ground sunrise. The field-strength as well as number were found to be minimum from about 12 to 2 in the day. One maximum both in number and field-strength was observed some minutes after the ground sunset. In some observations, a maximum appeared about the time of ground sunset.

A general explanation has been given of the observed maximum before the ground sunrise and after the ground sunset in terms of the changes in the ionospheric conditions during the transition period. The two maxima observed could be associated with the E- and the F-layers. According to this view, it has been possible to locate the source of the distant atmospherics from the observed position of the maximum in relation to the ground sunset or sunrise. The basic idea in this explanation has been verified by observing the position of the field-strength maximum for short-wave signals from the Calcutta station during and after the sunset time.

III. The frequency distribution of the atmospherics from the east-west direction was studied in two different ranges of frequencies, viz., 2 Mc. – 5 Mc. (60 m – 150 m) and 10 Mc. – 20 Mc. (15 m – 30m) under the following heads:

(a) Measurements of field-strengths of distant atmospherics during day and night.

(b) Measurements of field-strengths of the atmospherics of near origin during local thunderstorms.

(c) Measurements of field-strengths of the "rain-statics," when there was continuous drizzle with slight flashes but with no thunder.

All the experimental results on the frequency distribution of the atmospherics in the different cases have been satisfactorily explained.

IV. The average values of the daily maximum peak-strength of the atmospherics on 5 Mc. and 10 Mc. during the usual morning, afternoon and night programme hours for the monsoon months were determined and an estimate of the signal-strength values for good reception about this time at Dacca on these frequencies has been made from these averages.
A

KHASTGIR, S. R., and P. M. Das. Periodic fading of short-wave radio signals. Proc. Phys. Soc. 63B, 924-930 (1950).

Periodic fading patterns were recorded photographically with Calcutta signals of frequency 4,840 kc/s. received at Dacca (distance 240 km.) during the evening and early night hours of December 1948 and January 1949. The main features in the experimental conditions were: (i) the operating frequency was much less than the maximum usable frequency (M.U.F.) for the F layer transmission, (ii) the frequency was slightly greater than the M.U.F. for the ordinary wave transmission through the E layer and (iii) it was slightly less than the M.U.F. for the extraordinary wave transmission through the E layer between the transmitting and receiving stations. The following patterns of periodic or rhythmic fading were observed:

(i) Sinuous fading of comparatively quick period: this is considered to be of magneto-ionic origin, due to the interference between the upper and lower trajectory extraordinary waves in the E layer, the ordinary waves having passed through the E layer.

(ii) Periodic or rhythmic fading of comparatively slow period: the slow periodic fading is considered to be due to the beat-effect between the singly and doubly reflected waves from the F2 region or between the singly reflected waves from the E and F2 regions, the two interfering waves in different directions having suffered different amounts of Doppler change of frequency due to the vertical movement of the ionospheric layer or layers. The vertical velocity of the ionosphere as computed from this view agrees with the observed value.

(iii) Slow periodic fading with superposed ripples : this was observed when the ionospheric conditions were favourable for the simultaneous occurrence of the magneto-ionic type of sinuous fading and the Doppler beat type of slow periodic fading. In a few patterns of periodic fading there was evidence of extremely high frequencies (4—12 cycles/second) the origin of which is unknown.
A

KHASTGIR, S. R., and R. S. Srivastava. Energy spectrum of atmospherics and attenuation of different low frequencies with distance. Proc. Nat. Inst. Sci. Ind. 26A, Suppl. II, 58-66 (1960).

Experiments to study the energy spectrum of different atmospherics and the attenuation of different frequencies (3—15 kc/s) over widely varying distances (150—1,500 km.) during the night hours were carried out at Banaras. The method and the experimental procedure have been described. Considering only those atmospherics which gave smooth and continuous amplitude variations in the narrow-band amplifiers, and which showed at the same time return stroke pulses with successive ionospheric reflections in the automatic atmospherics recorder, the energy spectrum curves were drawn for the individual atmospherics originating at various distances which were estimated from the time-intervals between successive ionospheric reflections in the wave-form records. The frequency for which the maximum amplitude was observed was found to increase almost linearly with the distance. The attenuation curves were also drawn for 6, 7, 8, 9 and 10 kc/s relative to 12 kc/s over a distance ranging from 150 to 1,500 km. The curves are not very different from Budden's theoretical curves.
A

KHASTGIR, S. R., and R. N. Singh. The size of the moving irregularities in the F-region and the spread angle of the radio waves scattered from them. J. Atmos. Terrest. Phys. 18, 123-126 (1960).

The three-spaced receiver fading records of the F-echo at 3·8 Mc/s, taken at Banaras during the period from November 1956 to September 1958 show certain characteristic patterns. The fading patterns which were considered as due entirely to the movement of large ionospheric irregularities are analysed by the method of Briggs and Phillips (1950). As a result of this analysis the average characteristic length of the irregularities is found to be 270 m and the average angular spread is found to be 6°. The variations of these parameters are shown with the help of histograms. The records show some diurnal and seasonal variations, but no definite conclusion can be made regarding such variations.
A

KHASTGIR, S. R., and Y. S. N. Murty. Left-handed ionospheric echo from an equivalent height of E+F. J. Sci. Indus. Res. 18, 304-305 (1960).

In 1956 Satyanariya and others reported experiments made in the night and early morning hours with a 3 Mc/s pulsed transmission directed vertically. The experiments suggested a new type of left-handed echo from the Es and F regions with an equivalent height of 2 F—E. The authors of this paper discuss what happens to the two parts of the ordinary component of a vertically directed wave after reflection and transmission in the Es region: they conclude that the most likely path would lead to a reception at the ground of a left-handed echo with an equivalent height E + F.
PA

KING, J. W. Magnetic effects in the F-region of the ionosphere. J. Atmos. Terrest. Phys. 21, 26-34 (1961).

Plots of f_0F2 vs. the equivalent planetary daily amplitude, A_p, show that at night f_0F2 decreases as the magnetic disturbance increases. During the midnight period an A_p of 35 is found to reduce the ionization below the value corresponding to zero magnetic disturbance by an amount within a few percent of 65 per cent in all seasons and for all the stations investigated.

The "half-life" of the ionization as deduced from critical frequency values during the night is shown to be dependent on the value of A_p, and decreases from 5·0 hr for nights of small magnetic disturbance to about 3·0 hr for disturbed nights. The amount of magnetic disturbance thus controls both the amount of ionization present before midnight and the fraction of this transferred to the next day. It is shown that this mechanism could be responsible for the day-to-day correlation of f_0F2 values.

A method for selecting ionospherically quiet and disturbed days is suggested, and it is shown that the magnetically selected 5Q days are not generally ionospherically quiet; the days immediately after the 5Q days are much more likely to be ionospherically quiet. It is shown that during the midday period the median critical frequency is the frequency corresponding to no magnetic disturbance, while days which are disturbed may have frequencies which are greater or smaller than the median, the amount greater or smaller depending on the value of A_p.

The greatest variability of the ionosphere is shown to occur at night rather than during the day; this, together with the fact that plots of f_0F2 before midnight unexpectedly form a set of divergent curves, is due to magnetic effects.
A

KING, J. W. Day-to-day and station-to-station correlation of ionospheric F-region critical frequencies. J. Atmos. Terrest. Phys. 21, 35-39 (1961).

The cross-correlation of f_0F2 observed at different stations is found to have a diurnal variation with two maxima and two minima each day. The phase of this variation appears to exhibit a seasonal change with reversals of direction at the equinoxes. The mean cross-correlation coefficient is 0·5 for stations on the same north-south line and separated by 2000 km, and also for stations having the same latitude and a separation of only 1000 km. The diurnal variation of cross-correlation is shown to be unrelated to solar tidal effects.

The auto-correlation of critical frequencies from a single station indicates that there is an important relationship between the value of f_0F2 at a particular hour and the value at the same hour on the day before. The diurnal variation of the auto-correlation coefficient has maxima at 0700 and 1900 hours and minima at 1300 and 0100 hours, and exhibits no seasonal change. This correlation is probably due to magnetic effects which determine the amount of ionization carried over from one day to the next.
A

KING, J. W., and C. Graham. The relationship between f_0F2 and magnetic phenomena. J. Atmos. Terrest. Phys. 24, 107-115 (1962).

It is shown that on non-stormy days the relationship at night between the equivalent planetary daily amplitude, A_p, and the amount of ionization present at the maximum of the F-layer at temperate latitudes is a striking inverse one, except for a short "anomalous" period during the three mid-winter months when the relationship becomes positive. This relationship suggests a daily correlation of critical frequencies at northern and southern temperate latitudes of the kind which is shown to exist. The seasonal variation of this daily correlation of critical frequencies is explained.

It is shown that the general seasonal relationship between f_0F2 and A_p is similar over a wide range of latitudes, and also for both day and night-time data. It appears that effects on storm days can be predicted by simply extrapolating the data for non-stormy days, indicating that magnetic effects produce a certain amount of ionospheric disturbance at all times.

Because magnetic activity produces a decrease of f_0F2 below the normal value in summer, and an increase in winter, the ratio of mean f_0F2 winter/mean f_0F2 summer is substantially bigger than that for the undisturbed ionosphere.

The relationship between A_p and f_0F2 gives rise to an equation

$$\text{standard deviation of } f_0F2 = 0{\cdot}7 \times \text{standard deviation of K-index}$$

which is applicable to night-to-night variations during a month. It is shown

that the apparent general night-time and day-time relationships between A_p and f_0F2 are different.

The regular diurnal variation of the correlation between the critical frequencies observed at two stations having the same longitude and situated 1700 km apart is indicated and an explanation suggested.

It is shown that A_p exhibits marked auto-correlation from day to day; this phenomenon is probably partly responsible for the day-to-day correlation of f_0F2 observed at a single station.

A

KING, J. W. Some relationships between magnetic and ionospheric variations. IN: Proc. International Conference on the Ionosphere, London, July 1962, 116-119 (The Institute of Physics and the Physical Society, London, 1963).

The different night-time and day-time relationships between f_0F2 and magnetic activity are described. It is shown that the quantity Δf_0F2 does not have the same significance by day as at night. The apparent rate at which ionization is lost in the F layer at night is shown to depend on magnetic activity as well as on the height of the layer, and the apparent loss rates by day and by night are shown to be sharply contrasted. The average changes in the height of the F2 layer peak which occur during storms have been investigated and negative storms, which generally occur at middle latitudes in summer and at higher latitudes for most of the year, are shown to be associated with layer heights which are higher than normal.

A

KIRBY, R. S. Long-term characteristics for air-ground propagation in band nine. 1963 PTGAP International Symposium Program and Digest, Boulder, Colo., 9-11 July 1963.

Commencing the 1961-1962 school year, the Midwest Program on Airborne Television Instruction, Inc. (MPATI) transmitted television signals from an aircraft flying over Indiana at 23,000 feet. The primary purpose of this experiment was to test the effectiveness of the airborne broadcast technique in providing television instruction over a large geographic area.

The Central Radio Propagation Laboratory of the National Bureau of Standards became interested in tho program in its early planning stages, and under sponsorship of the Ford Foundation made studies of some of the technical factors involved in air-ground broadcasting and in the planning of an airborne television network (Decker, 1959 and 1962).

The purpose of this paper is to describe a series of propagation measurements made over several air-ground propagation paths during the 1961-1963 period. Altogether six continuous recordings have been made at four locations ranging from 87 to 222 miles from the transmitter.

Two transmitters operate simultaneously on Channels 72 and 76 while the aircraft orbits at 23,000 feet over Montpelier, Indiana. All recordings of transmission loss are made on paper charts, which are later transferred to magnetic tape.

Excerpt

KLEMPERER, W. K. Ionospheric cross-modulation at the geomagnetic equator. Paper presented at Conference on Non-Linear Processes in the Ionosphere, 1963, National Bureau of Standards, Boulder, Colo. 16-17 Dec. 1963.

Various experiments to detect radiowave interactions in the lower ionosphere have been carried out using the 22-acre antenna and 4-megawatt transmitter of the Jicamarca Radar Observatory. Although equatorial sporadic-E severely limits observation time, reduction in the amplitude of 3Mc/s F layer echoes by as much as 25% is readily obtained from the classical Luxemburg effect. Cross-modulation of 50 Mc/s cosmic noise has also been obtained. In this experiment the lower ionosphere is first heated slightly with a 12 KiloJoule r.f. pulse. A decrease in sky brightness temperature (about 6,000° K. well away from the galactic center) of 30° ± 10° K. is occasionally observed with a recovery time on the order of 2 milliseconds. Both the Luxemburg and cosmic noise observations indicate that the interaction height is about 75 km. This is in agreement with theories of D-region formation attributing most of the lower level ionization to cosmic ray influx. At the geomagnetic equator we are shielded from most of these particles (those with energies below 15 Bev). The amount of attenuation suffered by a second frequency f as a result of the 50 Mc/s heating pulse is proportional to f^2 and is a linear function of the applied power.

Three other experiments of an exploratory nature for the detection of "sidebands" or combination frequencies near the electron "gyro-frequency" were carried out. No such effects were observed.

A

KNAPP, D. G. Some IGY geomagnetic results in the Pacific and a suggestion as to the origin of the equatorial electrojet. U. S. Dept. of Commerce, Coast and Geodetic Survey, Washington, D. C. (1959).

No abstract available.

KNAPP, D. G., and J. W. Gettemy. A new longitude effect in the geomagnetic solar daily variation. J. Geophys. Res. 68, 2411-2420 (1963).

The daily variation of geomagnetic vertical intensity (Z) at Koror, Palau Islands, slightly south of the dip equator, is characterized by a positive salient before 1100 hours and a negative one after 1500 hours. This feature, which persists throughout the year, appears to reflect a component of the Z curve that simulates the time derivative of the horizontal-intensity (H) curve. A similar though less pronounced effect may be discerned at Huancayo and at Trivandrum; at Addis Ababa its sign is reversed. This component probably makes inapplicable to Koror (and possibly to some other localities) the suggestion advanced by Osborne that the day-to-day fluctuations in the ratio of Z and H ranges in western Africa may reflect shifts in the latitude of the electrojet. To account for the observed Z effect it is suggested that there is superimposed on the conventional S_q pattern of ionospheric currents a north-south flow of current confined to the daylight side of the earth, that this current reverses its sign in a systematic relation with the earth's rotation, and that it may tend to channelize along the paths established by the S_q patterns, so as to become manifest in the daily-variation curves at stations in higher latitudes as well as along the dip equator. On the basis of the relative amplitudes of the eastward and westward salients of magnetic declination curves, the suggestion is strongly supported as regards Europe and the western hemisphere; but equivocal results are obtained for Australasia and the western Pacific, notwithstanding that Koror in this region exhibits the Z effect more strongly than any other equatorial station. Neither the source of the postulated current nor the path by which its circuit is completed is clear. It is conjectured that a persistent leakage of charged particles trapped in the magnetosphere, falling from their mirror points into the upper air, may give rise to vacillating potential differences between the northern and southern auroral zones, and that the phenomena here reported represent the ebb and flow of ionospheric current required to equalize these potential differences.
A

KNECHT, R. W., and D. W. Schlitt. Early results from the equatorial close-spaced chain of ionospheric vertical sounding stations. NBS Rept. 5587, National Bureau of Standards, Boulder, Colo. (1958).

A chain of five vertical sounding stations has been established along the magnetic equator in South America for the IGY to determine better the nature and extent of the ionospheric anomalies occurring in the equatorial region. The purpose of this study is to take an early look at the data being obtained along the chain while the experiment is still in progress and there is yet time to influence the program for the remaining months of the IGY. Excerpt

Topics included are monthly median of f_0F2, electron density profiles, equatorial spread-F echoes, equatorial Es, and other features of the equatorial ionosphere.
C

KNECHT, R. W. An additional lunar influence on equatorial Es at Huancayo. J. Atmos. Terrest. Phys. 14, 348-349 (1959).

Observations at Huancayo, Peru, are presented to show additional influence of the moon on the sudden day-time disappearance of equatorial Es. An example of its is characterized and illustrated by an ionogram. The analysis of the observations of May 1957 to April 1958, illustrated also by a diagram, support Matsushita's theory that equatorial Es was caused by vertical upward drift forces due to eastward flowing electric currents and his supposition that westward flowing currents caused by lunar tidal forces might weaken the equatorial Es.
MGA

KNECHT, R. W. Possibility of detecting ionospheric drifts from the occurrence of spread F echoes at low latitudes. Nature 187, 927 (1960).

During the course of an investigation concerning the geographical extent of the scattered and diffuse echoes frequently observed during the night hours at high and low magnetic latitudes (spread F) and interesting phenomenon was observed. Times of occurrence of spread F echoes on ionospheric soundings taken every 15 min. during September and October 1957 at four stations in Peru (Talara, Chiclayo, Chimbote and Huancayo—average separation about 350 km., magnetic dip from 2° to 13°) strongly suggested that the patches of irregularities thought to be producing the spread F were often observed successively at each of the four stations. For example, an occurrence of spread F might be observed to begin at, say, 0015 hr. at Talara, the north-westernmost station, at 0045 at Chiclayo, at 0100 at Chimbote and at 0145 at Huancayo, the south-easternmost station. This tendency was particularly marked for the relatively short occurrences

(less than about 2 hr. in duration) that were commonly observed during the latter half of the night. As the stations were located approximately along a straight line, it is not possible to deduce unambiguously the magnitude and direction of the suggested drift. It has been shown, however, that the geographic north-south component of the night F region drift is usually small at these latitudes. Therefore, on the assumption that the drift was wholly in the magnetic east-west direction, magnitudes of the geographic east-west component of the apparent drifts indicated by the spread F occurences during September and October have been estimated. A mean apparent drift velocity of 135 m./s. towards the east was obtained for period 0000-0400 hr. Skinner, Hope and Wright, using the Mitra technique at another equatorial location (Ibadan) during the same period, observed a mean east-west component of F region drift of about 110 m./s. towards the east. The degree of agreement suggests that drifts, either of the patches of irregularities giving rise to the spread F echoes or of the disturbance producing the irregularities, may play an important part in the occurrence of spread F at low latitudes.

A more comprehensive study of spread F occurrences along the Peruvian chain of stations during the International Geophysical Year period, including a full interstation correlation analysis, is now being completed and will be published elsewhere.

Excerpt

KNECHT, R. W., and R. E. McDuffie. Solar flare effects in the F-region of the ionosphere. J. Phys. Soc. Japan 17, Suppl. A-I, 280-285 (1962).

The large solar flares of November 12 and 15, 1960, were accompanied by prominent F-region ionospheric effects at several locations. These flares were also notable in that large sea-level cosmic ray increases were observed shortly after the flare beginning, however, the times of the F-region effects agree with the times of the optical flares rather than the arrival of the cosmic rays. Of the eight earlier solar flares associated with sea-level cosmic ray increases, at least two others also were accompanied by F-region effects (November 19, 1949 and February 23, 1956). Evidence is presented that suggests that the height of the F layer at the time of the solar event may play a role in determining whether an effect is seen at any given location.

J Res. NBS

KNECHT, R. W. Topside soundings of the ionosphere. J. Phys. Soc. Japan 17, Suppl. A-1, 302 (1962).

Relative to the presence of irregularities and ducts in the F-region mentioned by Dungey, I would like to describe briefly a recent rocket experiment involving radio pulse reflections from the topside of the ionosphere.

A sounder pulsing at two fixed frequencies, 5.97 Mc/s and 4.07 Mc/s, was carried to an altitude of 1060 km at about 1800 local time on June 24, 1961 at Wallops Island, Virginia. The sounder was above the peak of the F layer for about 15 minutes. During 1. of these 15 minutes, good reflections were obtained on one or both frequencies from the topside of the F layer. Exceptionally strong returns with apparent multiple reflections, which were observed shortly after "breaking out" of the topside of the F layer, suggests that the field-guided mode of propagation may have been present. The second point I wish to make concerns irregular scattered returns that were observed as the sounder passed through the 750—950 km region on both upgoing and downgoing portions of the flight. These overvations suggest the occurrence of ionization irregularities in this altitude region. The flight took place during quiet magnetic conditions; however, a moderate magnetic storm had occurred two days earlier.
J.Res.NBS

KNECHT, R. W., and R. E. McDuffie. On the width of the equatorial E_s belt. IN: Smith, E. K., and S. Matshushita, ed. Ionospheric Sporadic E, 215-218 (Pergamon Press, Inc., New York, 1962).

This short paper reports an analysis of two years observations of equatorial sporadic E taken at a chain of vertical soundings stations in the vicinity of the magnetic equator in Peru. The results suggest that equatorial E_s occurs in a belt having a width of about 700 kilometers which agrees very well with the width for the equatorial electrojet as deduced from geomagnetic observations.
J.Res.NBS

KNOX, F. B. A contribution to the theory of the production of field-aligned ionisation irregularities in the equatorial electrojet. J. Atmos. Terrest. Phys. 26, 239-249 (1964).

A theory is developed which shows that in the presence of crossed electric and magnetic fields fluctuations of ionisation density may increase in amplitude where gradients of mean ionisation density or electric field exist. When the theory is applied to the situation occurring in the equatorial electrojet it predicts the growth of irregularities of ionisation density of a type which may have been observed there. The irregularities can occur with wide range of velocity.
A

KOIZUMI, T., and H. Ohyama. Study in the stratification of F region. J. Radio Res. Lab. Japan 10, 37-67 (1962).

A study in the stratification of F region is made on the suggestion of the World Wide Sounding Committee of the U.R.S.I. The analysis is focussed on several stations representing the characteristics of various latitudes, by utilizing mainly the monthly tabulation sheets and the f-plot for the period of the sunspot maximum.

The results obtained are as follows:

(1) Concerning the latitudinal and seasonal dependence of stratification of F region, the occurrence of stable stratification is very often observed in high latitudes during the summer season. The cases decrease with a descent into lower latitudes, and there are very few in other seasons even in high latitudes.

(2) In the yearly variation, the frequency at stratification in middle latitudes is noticed to show slightly the semi-annual variation, corresponding to the solar zenith angle, although the former investigations insisted upon only the existence of annual variation.

(3) The stable stratification appears in the case of low value of f_0F2. If the value of f_0F2 at noon is less than 8 Mc/s, the stratification on that day is likely to be stable.

(4) In the forecasting work of MUF concerned with the radiocommunication circuits, the possibility is examined to replace (M 3000)F2 by (M 3000)F which is obtained in dividing F1-3000 MUF by f_0F2, not by f_0F1, to abolish the scaling of F1-3000 MUF. The results show that the replacement in high latitudes is impossible, because the monthly median value of MUF is changed. On the contrary, it can be said that the replacement is considered possible in the middle and low latitudinal zones.

Therefore, the stratification of F region in the high latitudinal zone will be distinguished from those in the middle and low latitudinal zones. Since these results were obtained by the analysis at the sunspot maximum period, the same study should be made at the forthcoming sunspot minimum period in order to grasp the secular variation of stratification of F region on a world-wide basis.

A

KOSTER, J. R., and L. R. O. Storey. An attempt to observe whistling atmospherics near the magnetic equator. Nature 175, 36-37 (1955).

No whistling atmospherics have been observed at Achimota, Gold Coast (geomagnetic latitude 10°N) over a three-year period when other observations

indicated that they were common in middle latitudes. This is in agreement with the Barkhausen-Eckersley theory of the production of whistlers.
PA

KOSTER, J. R. Radio star scintillations at an equatorial station. J. Atmos. Terrest. Phys. 12, 100-109 (1958).

Radio star scintillations have been observed at a frequency of 45 Mc/s over a period of 4 years at an equatorial station with a phase switching interferometer. Scintillation effects are found to be very severe, the output from even intense radio stars often dropping to zero. Scintillation occurs only at night, and is of nearly daily occurrence near sunspot maximum, correlating positively with the sunspot cycle. It correlates highly with the occurrence of spread-F echoes, but with no other geophysical phenomena. It is as yet unclear whether the observed results are due to absorption of the signal or can be accounted for by the impression of a much larger phase deviation on the emergent wave front by the diffracting screen responsible for scintillation. The phenomenon correlates highly with the transequatorial scatter of radio signals observed near sunspot maximum.
A

KOSTER, J. R., and R. W. Wright. Scintillation, spread F, and transequatorial scatter. J. Geophys. Res. 65, 2303-2306 (1960).

Radio-star scintillations of great intensity are a common occurrence at the equator. Near the minimum of sunspot activity they exhibit little dependence on magnetic activity, but as sunspot maximum approaches there is a marked negative correlation between the occurrence of scintillation and the degree of magnetic disturbance. Radio-star scintillation is found to be much greater at sunspot maximum than at sunspot minimum.
A

KOSTER, J. R., and R. W. Wright. Scintillations of radio stars and magnetic activity in Ghana. Ann. IGY, 1957/1958 11, 106-109 (1961).

Radio star scintillations of great intensity and frequent occurrence have been observed at an equatorial station. These scintillations are similar to those observed at higher northern latitudes; their difference lay in the fact that the equatorial variety not only causes the output from a phase switching interferometer to exhibit random fluctuations, but is manifested by the diminution of the sinusoidal trace due to a radio star. Very little has been reported with respect to radio star scintillation at low latitudes, but in 1954 it was found that in Hawaii scintillations tended to increase during magnetic storms.
MGA

KOSTER, J. R., and R. W. Wright. Radio star scintillations and associated effects in equatorial regions. IN: Aarons, J., ed. Radio Astronomical and Satellite Studies of the Atmosphere, Proc. Corfu Summer School, 17-29 June 1962, sponsored by the Scientific Affairs Division, NATO, 114-134 (North-Holland Publishing Co., Amsterdam, 1963).

A review is given of the work performed on scintillations near the magnetic equator. Sample observations are discussed and the mechanism involved indicated. The experiments using spaced receivers give a great deal of further information concerning the irregularities in the ionosphere, when applied either to radio stars or satellites. The variation of scintillations at the equator with time of day, season, sunspot cycle and magnetic activity is indicated. The behaviour of scintillations is compared to other effects such as "flutter fading", Doppler shift measurements and spread-F. The little knowledge regarding the world-wide distribution of scintillation is discussed.

Throughout the paper stress is laid on the unsatisfactory position of our present knowledge of scintillation in equatorial regions.
A

KOSTER, J. R. Some measurements on the sunset fading effect. J. Geophys. Res. 68, 2571-2578 (1 May 1963).

The sunset fading effect, or flutter fading, is a phenomenon sometimes observed on radio signals reflected from the F region of the ionosphere when the reflection point is near the magnetic equator. The effect has been investigated in Ghana using direct observation of the carrier level, a fading-rate meter, and the Doppler fading technique. It is found that flutter fading occurs between sunset and midnight, has equinoctial maximums, and correlates positively with the sunspot cycle. The fading rate is directly proportional to the frequency. It is suggested that coherent scatter from elongated irregularities could account for the observed correlation with radio-star scintillations and for the Doppler fading results.
A

KOSTER, J. R. Some measurements of the irregularities giving rise to radio-star scintillations at the equator. J. Geophys. Res. 68, 2579-2590 (1 May 1963).

Equatorial radio-star scintillations are shown to have maximums near the equinoxes. Measurements on summertime irregularities show them to be elongated along the earth's magnetic field, with an axial ratio of 7.5 or greater. Transverse sizes are of the order of 0.5 km. Velocities of drift are normally from west to east at night, with a mean value of 75 m/sec.

The pattern on the ground drifts with remarkably little change. Velocity decreases with time of night, and the pattern size on the ground increases.
A

KOTADIA, K. M. Sporadic echoes from the E region over Ahmedabad (23°02' N, 72°38' E). J. Atmos. Terrest. Phys. 8, 331-337 (1956).

In this paper, a study is made of the sporadic E echoes observed in the ionospheric h'-f records of Ahmedabad ($\phi = 13 \cdot 6$°N). From the analysis of the data for 1953-1954, a sunspot minimum period, it was found that three types of sporadic, namely (i) Esc at 95-100 km, (ii) Esn at 105-125 km, and (iii) Ess at 115-125 km, occur in the E region. The overall behaviour of Es has been shown as being due to the combination of the characteristics of these three types. The sporadic ionization of type Esc has a maximum frequency of occurrence in the late evening hours, and has a thin structure. It is apparently evolved out of a downward drift of the residual ionization of the normal E layer. No correlation could be established with meteor activity. Esn shows a minimum in the afternoon and maximum in late-night hours before dawn. Ess is developed by the vertical downward movement of the E2 layer.
A

KOTADIA, K. M. The ionospheric F2 layer over Ahmedabad, Delhi and Tiruchirapalli during the sunspot minimum period (1953-1954). J. Sci. Indus. Res. 15A, 543-550 (1956).

Describes general character of F2 over Ahmedabad during sunspot minimum of 1953-54. Finds sunrise effect on F2 delayed by about 25 min after layer sunrise in summer, but occurs during layer sunrise in winter. Plots daily variation of f_0F2, h'F2, and hpF2 month by month. Plots daily variation of forked or spread F2 echoes, finds maximum occurrence at about 0300 hr. Also plots mean range of variation of height and frequency parameters. Compares with records at Delhi and at Tiruchirapalli.
M

KOTADIA, K. M. The intermediate layer of stratification ($F_{1.5}$) between F_1 and F_2 at Ahmedabad. Proc. Indian Acad. Sci. 66, 349-353 (1957).

A summary of our knowledge of the so-called $F_{1.5}$ layer (intermediate between F_1 and F_2) is contained in the report of a discussion on "Solar Eclipses and the Ionosphere" held in London in August 1955. The $F_{1.5}$

layer is frequently observed during solar eclipses at places where the magnetic dip is less than 20°. Japanese workers reported the occurrence of $F_{1.5}$ at higher dip angles.
Excerpt

KOTADIA, K. M. Spread-F in the ionosphere over Ahmedabad during the years, 1954-1957. Proc. Indian Acad. Sci. 50, 259-271 (1959).

From a study of spread-F or F-scatter at Ahmedabad during the four years 1954-57 of increasing sunspot activity, it was found that the time of its maximum occurrence receded from 03 hr. in low sunspot years to an hour or two before midnight in high sunspot years. This was particularly well seen in the winter and equinoctial months. Also, maximum spread-F activity which was found in summer in sunspot minimum years, occurred in equinoxes in maximum sunspot years. The frequency of occurrence of spread-F was found to be a maximum when hpF_2 was in the range 300-350 km. F-scatter and F_2-stratification were found to be anti-correlated both in their diurnal and seasonal variations. The general trend was towards decreased spread-F with increased sunspot activity.

It is concluded that (1) spread-F at Ahmedabad geomagnetic latitude (ϕ = 13·6° N) undergoes variations similar to those at equatorial stations, more so in high sunspot years, (2) the change-over from low-latitude type to middle-latitude type of variation of spread-F takes place at about geomagnetic latitude 22°, and (3) spread-F at Ahmedabad decreases with increase in magnetic activity, which is the reverse of that observed at high latitudes.
A

KOTADIA, K. M., and K. R. Ramanathan. Magnetic and ionospheric disturbances in low latitudes. Ann. IGY, 1957/1958 11, 68-82 (1961).

The report contains a brief summary of studies on the meridional profiles of f_0F2 and hpF2 in the eastern zone in different seasons of the years 1954 and 1957, and at different times of the day. The daily variation of the f_0F2 equatorial anomaly is discussed. It has been found that the effect of magnetic disturbances is to reduce the subequatorial anomaly. From a statistical study of f_0F2 data on magnetically disturbed days, it has been shown that the increase of day-time f_0F2, which takes place near the equator, changes to a decrease at about geomagnetic latitude 7°N, or magnetic dip 20°N. This is also the latitude at which the phase reversal of lunar variation of f_0F2 occurs. Sudden disturbance (SD) variations of f_0F2 at Ahmedabad are derived from records of days of sudden commencement (SC) type magnetic storms, and also from other magnetically disturbed days, and compared with results obtained at other places. Storm time variations (Dst) are also studied. The occurrence of spread-F at Ahmedabad

is found to decrease with increase in magnetic activity; the opposite to that at Slough. The change-over takes place somewhere near magnetic dip 45°N or geomagnetic latitude 25°N.
MGA

KOTADIA, K. M. The equatorial sporadic-E layer and the electrojet. J. Atmos. Terrest. Phys. 24, 211-218 (1962).

In this paper, an analysis is made of E_s data from three chains of ionospheric stations near the magnetic equator in three different longitudes. Some of the stations were set up during the IGY period. The analysis shows that the electrojet as judged by the diurnal range of H, extends up to ±7° magnetic dip from the magnetic equator in high sunspot years and only to ±5° in low sunspot years. A dependence on longitude and a seasonal displacement of the peak of E_s ionization in this narrow zone are observed.

There are many similarities between the variations of E_s ionization and the horizontal component of the earth's magnetic field near the magnetic equator. Some differences are, however, found in their seasonal and sunspot-cycle variations.
A

KOTADIA, K. M. Lunar tidal variation of midday critical frequencies of the F2-layer of the ionosphere in low latitudes. J. Atmos. Terrest. Phys. 24, 659-661 (1962).

The variation of noon f_0F2 with lunar phase for the sunspot minimum year 1954 shows a predominantly semi-diurnal component at six Indian stations. The phase reverses somewhere between Bombay and Madras (about magnetic dip 20°); the amplitude has two maxima, one near the well-known f_0F2 peak and the other at the magnetic equator.
PA

KOTADIA, K. M. The great magnetic storm of 11 February 1958 and associated changes in the F_2-layer of the ionosphere in low and middle latitudes. J. Atmos. Terrest. Phys. 24, 975-988 (1962).

In this paper, the changes in the critical frequency of the F2-layer of the ionosphere which followed the sudden commencement of the great magnetic storm of 11 February 1958 are studied both with regard to storm-time and local-time variations at a number of stations from the magnetic equator to magnetic dip 72° in three different meridional sections. The changes are then examined to find the differences, if any, between places magnetically conjugate on either side of the magnetic equator and approximately along the same longitude. They are further

compared with variations in the horizontal component of the earth's magnetic field.

The disturbed-day variation of f_0F2 is the combined net effect of storm-time, disturbance-diurnal and seasonal variations. The changes in f_0F2 show distinct differences around 20° and 45° magnetic dips. There is no one-to-one correspondence between $\Delta(f_0F2)$ and ΔH. The local time of commencement of the storm has a marked control on the changes in f_0F2.
A

KOTADIA, K. M. On the F1 1/2-layer of the ionosphere. J. Atmos. Terrest. Phys. 25, 179-181 (1963).

In this note observational facts are presented to establish the reality of an F1 1/2-layer. Such a layer is more evident in low latitudes during high sunspot activity and is formed as a subsidiary in the main body of the deeply ionized F2-layer, possible due to the rapid change in the rate of loss of electrons with height. It is further suggested that the equatorial anomaly in the f_0F1 distribution reported by some workers in high sunspot years is probably the result of overlooking the distinction between F1 and F1 1/2 in past years.
A

KREVSKY, S., N. Artuso, R. Mason, and R. A. Thowless. Tactical jungle communications study. RCA Rept. CR-63-419-4, Defense Electronic Products, Radio Corporation of America, New York (March 1963).

Present HF and VHF inter-troop communications equipment are unsatisfactory for operation in tropical rain forests. This is a direct result of excessive path losses for ground-wave and "line-of-sight" propagation, caused by dense jungle growth and tall trees. Purpose of the study was to devise antenna equipment that would improve the operational range of reliable communications, between/to "man-pack" equipment in dense jungle areas.

Results of the propagation study are presented, showing the utility of vertical-incidence, HF sky-wave transmission. Antenna design and antenna-erection methods particularly suited for jungle-patrol and base-camp operations using this mode of propagation are also presented.

Erection methods for HF dipoles at suitable heights were studied. Simultaneous estimates were made of efficiencies for various heights above ground. Foreshortening techniques for HF dipoles were studied.

Simple wire antennas, 10 to 30 feet above ground, were found to provide good efficiency and satisfactory low-power, HF sky-wave communications, potential for most severe jungle terrain circumstances.

Emphasis was also given to techniques, such as balloon-borne dipoles, for obtaining useful line-of-sight VHF transmissions.

A

KREVSKY, S. H.F. and V.H.F. radio wave attenuation through jungle and woods. IEEE Trans. PTGAP-11, 506-507 (1963).

Using the expression loss in dB = 20 $\log_{10}e^{-d/\delta}$ where δ is the skin depth and d distance, the attenuation for both jungle and midlatitude woods at frequencies between 2 Mc/s and 100 Mc/s has been calculated and the results compared graphically against other investigators experimental results. A reasonable order of agreement was shown but it is noted that before making any attenuation predictions the nature of the woods must be accurately defined as there is a three fold order of magnitude difference in attenuation between dense jungle and mid-latitude woods in leaf; viz. at a frequency of 15 Mc/s the attenuation per 0·1 mile is 2 dB for midlatitude woods as against 35 dB for dense jungle.

EEA

KRISHNAMURTHI, M., G. Sivarama Sastry, and T. Seshagiri Rao. Abnormal ionospheric behaviour at 10 metres wavelength. Current Sci. 27, 332-333 (1958).

The radiation intensity of 10 m cosmic radio waves fell to zero on Jan. 28, -Feb. 21, and March 2, 1958 at the Physical Laboratories, Osmania University, Hyderabad, India (17°26'N, 78°27'E). The gradual fall of intensity occurred about sunrise time, and the rise of intensity toward end of the phenomenon was uniformly rapid in the three cases, but differed in duration of minimum noise level. Small scale irregularity in the upper ionospheric layers is offered as a plausible cause of this disturbance which is knowingly unrelated to any solar flare.

N

KRISHNAMURTHY, B. V., and B. Ramachandra Rao. The nocturnal and seasonal variations of spread-F. J. Atmos. Terrest. Phys. 25, 1-8 (1963).

The nocturnal variations of spread-F at Waltair using data over a period of 22 months (March, 1960-December, 1961) are studied and discussed in comparison with the variations at other equatorial stations. The seasonal characteristics of spread-F are studied separately for magnetically quiet and disturbed days, using data at four equatorial stations, namely, Waltair, Trivandrum, Madras and Bombay.
PA

KRISHNAMURTHY, B. V., and B. Ramachandra Rao. Time of onset of spread-F in relation to post sunset h'F variations. J. Atmos. Terrest. Phys. 25, 209-210 (1963).

It is a well known observation that at equatorial stations, the onset of spread-F is preceded by a marked rise in h'F and also that the spread-F maximum lags in time behind the h'F maximum. With a view to study if there is any relation between the time of onset of spread-F and time of occurrence of maximum value of h'F, observations were made at close intervals of 15 min on a few nights in each month during the period April, 1960—December, 1960. Such observations were available for 39 nights in total. The spread-F indices corresponding to these observations are obtained following the index system of Rao et al. (1960). When the indices on each night are plotted against time in I. S. T. along with h'F values, a very interesting and characteristic feature is revealed. It is found that the time of onset of spread-F and the time of occurrence of h'F maximum are more or less same. To examine this aspect more closely, the time of spread-F onset is plotted against the time of h'F maximum and the resulting plot is shown in Fig. 1.*

It can be seen from Fig. 1, that in general, the observations fall fairly well on a mean straight line. It is interesting to note that the agreement between the time of onset of spread-F and the time of h'F maximum is particularly good when spread-F occurs earlier than 2000 hours. The slope of the mean straight line is found to be 1·1 indicating that the two timings are nearly same.

*Fig. 1. Time of onset of spread-F vs. time of h'F maximum.
A

KRISHNAMURTHY, B. V., and B. Ramachandra Rao. Fading characteristics of spread-F echoes. J. Geophys. Res. 68, 1923-1926 (1963).

The fading characteristics of spread-F echoes have been investigated in considerable detail. The fading rate of the first prominent echo in the

spread-F patch is found to show little variation with its virtual height or with the extent of spreading in virtual height. From analysis of the amplitude distribution of spread-F echoes, the ratio between the steady and random components in the fading amplitude is found to be about 2.5; this ratio showed little variation with the extent of spreading in virtual height of spread F.
A

KRISHNAMURTHY, B. V., and B. Ramachandra Rao. Effect of magnetic activity and F region height changes on equatorial spread-F. IN: Proc. International Conference on the Ionosphere, London, July 1962, 310-315 (The Institute of Physics and the Physical Society, London, 1963).

Statistical estimates of the strength and nature of association of equatorial spread-F with magnetic activity and post-sunset height changes of the F region have been obtained. Spread-F in the pre- and post-midnight periods has been analysed separately and it has been observed that magnetic activity is better correlated with spread-F in the pre-midnight period than with spread-F in the post-midnight period. The results are discussed in the light of Martyn's theory of spread-F.
A

KRISHNAMURTHY, B. V., and B. Ramachandra Rao. Short wave c.w. transmissions as affected by spread-F conditions. J. Inst. Telecom. Engrs. (India) 9, 194-200 (May 1963).

Regular short wave c.w. transmissions from three stations, namely Bombay, Hyderabad and Madras, was received at Waltair and their fading characteristics studied in relation to the overhead spread-F conditions. It was found that the fading rates were higher under spread-F conditions, compared to those under normal conditions. Allowing for the time shifts in the occurrence of similar peaks in the fading rate and spread-F index temporal variations, a systematic linear increase of the fading rate with spread-F index was found. It was also observed that the c.w. transmissions in the E-W direction are more affected by spread-F conditions than the transmissions in the N-S direction. From amplitude probability distribution of the fading patterns, it was found that the steady to random component ratio was around 1·8 under spread-F conditions. These distributions under spread conditions were compared with those under normal conditions which are nearer to the Rayleigh type.
A

KUSHNEREVSKIY, Yu. V., and S. F. Mirkotan. Motions of ionospheric irregularities: a survey. Geomag. Aeron. 1, 405-426 (1961). (Original in Russian.)

Formerly there was a widespread opinion that intense motions (winds and turbulent mixing) were a characteristic property of the lowest layer of the atmosphere to heights of about 12 km. The grounds for this opinion were related to the fact that higher up, in the stratosphere, the variation of the temperature gradient with altitude is very small. Thus if the factor regulating the temperature in the bottom layers is convection, the temperature regime in the stratosphere and higher should be determined by absorption processes and solar radiation. As a consequence, the stratosphere was regarded as a relatively quiet medium divided into layers of different density. As early as the end of the nineteenth century, however, certain scientists presented data indicating the existence of motions in the atmosphere to heights of about 90 km. During the past two decades, the idea of the quiet state of the upper atmosphere has been radically changed by studies of meteor trails, noctilucent clouds, and the ionosphere using radio sounding techniques, as well as by observations of extraterrestrial radio emission and data on atmospheric structure obtained by rockets. The general name of upper atmosphere or ionosphere is applied to the higher layers of the atmosphere, in which ionization is important, i.e., above 60 km. Detailed information on the structure of the atmosphere and the variation of its properties and parameters with altitude can be obtained in special, comprehensive monographs.

The characteristic properties of the ionosphere to heights of about 500 km have turned out to be its variability and inhomogeneity. A whole range of irregular formations of electron concentration has been found, from a few meters, to tens, hundreds and even thousands of meters in size. Besides motions of a turbulent nature, these formations undergo regular horizontal and vertical motions.

Excerpt

LAITINEN, P. O., and C. W. Haydon. Analysis and prediction of sky-wave field intensities in the high frequency band. Tech. Rept. 9, U. S. Army Signal Radio Propagation Agency, Fort Monmouth, N. J. (1950, Third Printing 1956).

a. SCOPE. The purpose of this report is to present an engineering method of evaluating sky-wave field intensities in the high frequency band for any transmission distance up to about 15,000 kilometers. Field intensity recordings were statistically analyzed in order to study daytime absorption, day-to-day variations, and absolute magnitudes. Based upon the analysis, a proposed prediction method was obtained which should give relatively accurate sky-wave field intensities for the frequencies and distances considered. Succeeding sections show the method of analysis of absorption, the method of analysis of absolute magnitudes, the method of analysis of day-to-day variations, the proposed field intensity prediction method, and summarizing conclusions. All necessary equations used in the prediction method are represented in nomograms.

b. DATA. The data analyzed consists of monthly median receiver input voltages at one hour time intervals throughout the day and mass plots showing hourly median receiver input voltages in 2 decibel class intervals for the days of the month. The circuits analyzed are listed in Table 1. This table shows the period for which the data was available, the distance between the transmitting and receiving station, the wave frequency, and type of data. These records were continuous over a period of at least as long as one year. The circuit distances range from 55 to 15,000 kilometers and the frequencies from 0.7 to 20 megacycles per second. Eighty-three circuit years of monthly median hourly median receiver input voltages were used in the daytime absorption analysis. Data for 36 circuits, including information about transmitter output powers, transmitting antenna gains, and receiving system input characteristics were used in the analysis of absolute magnitudes. The receiving system installations were so designed as to make estimations of absolute magnitudes possible. Forty-three years of mass plot data was used in the analysis of day-to-day variations of hourly median field intensities. Other data not shown in the table covering a period from 1937 to 1944 was used in studying the relationship between daytime absorption and 12 month running average sunspot number.

c. THE METHOD OF ANALYSIS. This analysis is based upon the assumption that at high frequencies sky-wave field intensities can be computed by geometric optical methods. Various authors show the applicability of ray theory at these frequencies. Sky-wave propagation is a geometric rather than a diffraction problem since each plane on earth at distances greater than the skip distance is accessible by geometric trajectories. A method such as a residue series would be more applicable if a large number of geometric rays existed all having the same order of intensity. It has been shown by L. E. Beghian that, for high frequencies, only

a few rays are required and that under conditions of absorption the first ray approximates the field strength obtained by assuming all possible rays. When several ray paths exist having the same order of magnitudes, it is necessary to evaluate the field by summing the contribution of all the rays. Occasionally for long distances, the error in assuming that the field intensity can be represented by one ray alone can be relatively large since ray intensities of equal magnitudes are possible along several ray paths.
Excerpt

LAITINEN, P. O. Linear communication antennas. Tech. Rept. 7, U. S. Army Signal Radio Propagation Agency, Fort Monourth, N. J. (Revised 11 Oct. 1957).

This report is a consolidation of practical engineering equations for the absolute magnitudes of the fields produced by thin wire antennas. All the formulas are derived from the formula for the field of a differential (dipole) antenna. A derivation of this dipole field from Maxwell's field equations is also shown. By handling the reflection coefficients somewhat differently, a simple method for the field of an antenna erected near the earth is introduced. Antenna and ground system heating losses are accounted for by efficiency factors in the case of ground-based vertical and inverted "L" antennas. Curves are included for reflection coefficients, radiation resistances, and efficiency factors.

The antenna curves of Radio Propagation Unit Technical Report No. 2 were calculated by some of the formulas of this report. A comparison of curves of Report No. 2 and curves obtained from field measurements at Ohio State University is shown. Although the ground constants are somewhat different in the two cases, the space patterns are very nearly alike and the field intensities agree closely in magnitude.
Excerpt

LAKSHMINARAYAN, K. N. Short term time characteristics of impulse atmospheric noise. J. Sci. Ind. Res. 21D, 228-232 (July 1962).

The time duration and the time interval between peaks in the noise envelope voltage as received through a superheterodyne receiver having a bandwidth of 6 kc/s at 6 dB down was investigated at 110 kc/s, 300 kc/s and 3.0 Mc/s using a tape recorder and aural monitoring at Bangalore (12°58'N, 77°35'E). The results show that the distribution is log-normal for both. The mean value of the duration is about 500 msec. The mean value of the interval is expected to vary with the activity of local or near sources; for

the particular case investigated, it was about 1.4 sec. The results are compared with similar results reported by others and with the results of investigators on lightning discharges.
PA

LAL, C. Flutter fading of short-wave radio signals in equatorial regions and its connection with spread echoes, magnetic storms and the radiation belt. J. Inst. Telecom. Engrs. 6, 223-30 (1960).

The phenomena of "spread-echoes" on vertical incidence ionospheric soundings and "flutter-fading" on short-wave C. W. transmissions are of frequent occurrence in the low equatorial latitudes. Both the phenomena are predominant after local sunset and are inhibited during periods of strong magnetic activity associated with magnetic storms. A physical explanation is offered in this paper to the origin of these two phenomena in the following manner: Marked increase in the height of the F region of the ionosphere is almost a daily occurrence immediately after local sunset in low equatorial latitudes where the F region often ascends beyond 500 to 600 km. in the evening hours. The Allen radiation belt, recently discovered from satellite explorations, reaches down to a level of 500 miles or so from the surface of the earth over the equatorial regions. The F layer, during its upward ascent, is likely to touch the lower fringe of this radiation belt and since this belt consists of high energy charged particles, turbulence and patchiness in ionization may set in in the ionospheric layer. The irregular ionization and the turbulence may manifest itself as "spread-echoes" and "flutter-fading" of radio waves reflected from the disturbed portions of the F region. The explanation receives additional support from the fact that both "spread echoes" and "flutter-fading" are conspicuously absent at these latitudes during severe magnetic storms when the increase in the height of the F layer is inhibited and at times the F layer actually goes down appreciably. Various other observed characteristics of "flutter-fading" and its relation to "spread-echoes" have also been explained in the paper in terms of the Allen radiation belt in the exosphere.
EEA

LAL, C. Solar corpuscular activity and ionization density in the F2 layer of the ionosphere. Proc. IEEE 51, 1471-1474 (1963).

It is suggested that the ionization in the F2 region of the ionosphere is composed of contributions due to electromagnetic ultraviolet and corpuscular

radiations from the sun. These two components of solar energy can be represented by sunspot and geomagnetic activity. When contributions from both these components are taken into account, the monthly mean value of the averaged diurnal characteristics of f_0F2 is seen to follow fairly closely the combined effect of sunspot and geomagnetic activity, and the so-called "saturation effects" in the F2 region well nigh disappear. The monthly mean value of the diurnal average of $f_0F2(\overline{\Sigma f_0F2})$ is seen to vary according to the expression $\sqrt{R + 100} \times Ci$ throughout the solar cycle. In this expression R and Ci represent the monthly relative sunspot number and the international character figure for geomagnetic activity respectively.
A

LANGE-HESSE, G. Analysis of observed variations of absorption of electromagnetic waves in the ionosphere. Naturwissenschaften 39, 297-298 (1952). (In German.)

A calculation of the absorption factor for short waves (10-200 m or 30-1.5 MHz) shows that transmission is possible throughout the year near the equator, but in middle latitudes only in summer, when it can be forecast from sunspot number and 27-day cycle. In the auroral zone it is correlated with magnetic disturbances.
MGA

LANGE-HESSE, G. 27-Day variations in the absorption of the D region of the ionosphere over Singapore and Slough. J. Atmos. Terrest. Phys. 3, 153-162, 1963-1962 (1953). (In German.)

The absorption in the D-layer of the ionosphere is already known to change with the seasons and with the 11-year sunspot cycle. The question has therefore been examined, whether analogous variations occur in the course of the solar rotation of about 27 days in cases where the sunspots are unequally distributed in heliographic longitude (in such cases the sun exhibits, in the course of a rotation, alternatively aspects with many spots and with few spots). Such variations in absorption of appreciable amplitude are found at Singapore during the whole year, at Slough (near London), however, only during the summer months. Other variations in absorption of larger amplitude than in summer are found in Slough during the winter months, but these winter-time variations are not controlled by 27-days

variation in sunspot number R and also not by variations in particle radiation. The significance of these results in connection with radiocommunication circuits and for ionospheric forecasting is briefly discussed.
A

LAUTER, E. A. The atmospheric noise level in the longest wave region and its diurnal and annual variations. Z. Meterol. 10, 110-121 (1956).

Problems of the definition and measurement of the noise level are discussed from measurements of dependence on frequency, and statistics, of atmospherics. The dependence of the noise level on ionospheric conditions and on the frequency and position of centers of disturbance is shown from 3-year mean monthly diurnal variations on 14, 27 and 48 kHz. This shows that in winter the distribution conditions depend especially on the diurnal variation, but in summer on the approach of disturbance centers. Some remarks are added on geophysical peculiarities in the recording of atmospheric disturbances, such as interdiurnal variability, twilight effect and solar flare effect.
N

LEDIG, P. G., R. C. Coile, and M. W. Jones. The ionosphere at Huancayo, Peru, April to June 1941. Terrest. Mag. Atmos. Elec. 46, 351-354 (1941).

This report is a continuation of those already published in this Journal and gives monthly mean hourly values of the heights and penetration-frequencies of the ionospheric regions as obtained from the automatic multifrequency ionospheric recording apparatus located near Huancayo, Peru, South America, in latitude 12°02'.7 south, longitude 75°20'.4 west of Greenwich, which operates over a frequency-range 0.516 to 16.0 Mc/sec. A complete discussion of these data will be made in an annual summary.

Table 1 gives the monthly mean hourly values of the actual heights of maximum electron-density (h^{max}), uncorrected for retardation in lower regions, and the minimum virtual height (h^{min}) for both the F_1- and F_2-regions, the penetration-frequencies for the E-, F_1-, and F_2- regions, and the lowest frequency at which echoes were observed when the frequency was greater than 0.516 Mc/sec.

Figure 1 gives the data in graphical form; the values of h^{min} lie along the continuous line while those of h^{max} are indicated by the broken line.

The 75° west meridian standard times of sunrise and sunset at the Earth's surface for the middle of each month are shown by the broken vertical lines.

Table 2 gives root-mean-square values of F_2-region penetration-frequencies. Since ionization is proportional to the square of frequency, these data are more representative of average ionization than the normally used means of penetration-frequencies. The difference between the root-mean-square values of Table 2 and the arithmetical-mean values of Table 1 is an approximate measure of the scatter in individual observations during the month for that particular hour. Root-mean-square values for the E-region, F_1-region, and minimum frequency received have been discontinued because of the absence of appreciable differences between the root-mean-square and arithmetical-mean values.
A

LEDIG, P. G., M. W. Jones, and A. A. Giesecke. Effects on the ionosphere at Huancayo, Peru, of the solar eclipse of 25 January, 1944. J. Geophys. Res. 51, 411-418 (1946).

During eclipse measured ionospheric characteristics, formation of a new F2-layer was notable. It first appeared at great height and slight ion density, and swept downward until it was lower and more highly ionized than the regular F2-layer. Also observe recession in the pre-eclipse ionization build-up which they think possibly due to corpuscular eclipse. For alternative explanation see Wells and Shapley.
M

LEIGHTON, H. I., A. H. Shapley and E. K. Smith. The occurrence of sporadic E during the IGY. IN: Smith, E. K., and S. Matsushita, ed., Ionospheric Sporadic E, 166-177 (Macmillan Company, New York, 1962).

This paper presents maps of total E_s occurrence and considers the temporal variations of the E_s types observed on ionograms along a meridian chain of stations.
A

LEJAY, P., and J. Durand. Comparison of the results of ionospheric soundings at Bangui, Ibadan, Khartoum and Leopoldville. IN: Beynon, W. J. G., and G. M. Brown, ed., Solar Eclipses and the Ionosphere, 85-93 (Pergamon Press, Inc., London, 1956).

Results for the F2-region are compared for the eclipse of 25 February, 1952. At Bangui and Ibadan, those stations nearest to the magnetic equator, there is clear evidence for the appearance during the latter half of the eclipse of a new F2 stratification below the 'old F2'-layer. Although less marked, an analogous phenomenon is detected at Khartoum, but at Leopoldville (magnetic dip = 33.5° S) it is absent. Rapid increase in height of the 'old F2'-layer, without change of its critical frequency also seems to accompany the appearance of the 'new F2'-layer. Possible causes of this effect of proximity to the magnetic equator are considered.
PA

LEJAY, P. Ionospheric Irregularities. J. Atmos. Terrest. Phys. 15, 27-28 (1959). (In French.)

A systematic approach to solar phenomena in connection with irregularities of the ionosphere and earth magnetism is proposed. This approach includes separation of local time and the influence of the latitude in obtaining results on the development of ionospheric storms, and organization of telecommunication to solve the problems of differences between magnetic and ionospheric perturbations. The analysis of the critical F2 frequencies as currently used is not sufficient to distinguish the start of magnetic and ionospheric perturbations. The development of ionospheric storms at a given station, and the comparison of storms in different locations present other problems. The Geophysical Year presents an opportunity to organize the analysis of data obtained systematically.
MGA

LEMMON, M. J. H. Tropical-receiver design. Students' Quart. J. Inst. Brit. Elec. Engrs. 12, 24-31 (1941).

The general design of receivers for use in the tropics is discussed, special reference being made to the requirements for India. The main requirements of such receivers are high sensitivity, good a. v. c. characteristics, frequency stability, effective "magic eye" indication on short waves, large audio power output, tropic-proofed components and reliability in service. Suitable methods for securing these desirable features

are suggested, particular reference being made to compensation devices for minimizing frequency drift due either to a. v. c. action or to heating effects in the receiver components or chassis.

LEPECHINSKY, D. Effects of temperature variations of the upper atmosphere on the formation of ionospheric layers. J. Atmos. Terrest. Phys. 1, 278-285 (1951).

S. Chapmans' well known theory of ion production by photo-ionization of a gas with an exponentially decreasing pressure considers the case of a constant temperature. In the present paper a study is made of the effect of an increase of the mean temperature on the distribution of the rate of ion production at various heights. It is shown that at a given height, this rate is extremely sensitive to temperature changes and that it may go through a sharp minimum at midday if it is assumed that the temperature rises regularly from morning to midday. The two main effects of a temperature increase being a general elevation of the region where ions are produced and a general decrease of the rate of ion production. An estimate is made of the percentage of temperature increase which one has to assume to explain the higher summer altitude of the F_2 layer at midday as compared with its winter value, on the one hand, and its slight and gradual elevation between 6 a. m. and midday on a summer day, on the other. The percentages found (based on Slough 1950 records) are 46% and 21% respectively. It is further shown that the splitting of the F region into F_1 and F_2 may be due to a general temperature increase of the upper atmosphere. The "summer structure" of this region and the critical frequency drop of the F_2 layer during magnetic storms may similarly be considered as an effect of a temperature increase of the gas submitted to the photo-ionization process.

Finally it is pointed out that the seasonal variation of the absorption of short waves may also find an explanation in a seasonal temperature variation.

A

LEPECHINSKY, D. Ionospheric radio. Onde Élect. 35, 582-592 (1955). (In French.)

Report on the 7th meeting of Commission III of U. R. S. I. at The Hague. In addition to the resolutions passed the following subjects are summarized: ionospheric phenomena in high latitudes, structure of the D-layer and its

probable origin, movements in the ionosphere determined from the scintillation of radio-stars, rocket exploration, forward-scattering, geomagnetic anomaly in the ionosphere and possible interpretation, and preparations for the International Geophysical Year.
EEA

LEWIS, R. P. W., and D. H. McIntosh. Geomagnetic and ionospheric relationships. J. Atmos. Terrest. Phys. 4, 44-52 (1953).

The effect of magnetic "disturbance" on various parameters, both geomagnetic (measured at Eskdalemuir) and ionospheric (measured at Slough), is investigated by choosing days on which the K_v sum is markedly above or below those of adjacent days. Most of the parameters show a peak or trough corresponding to that of disturbance, and following it by periods of from 0 to 18 hours. An extension of the investigation to measurements made at Huancayo shows mainly similar results.

Particular attention is called to some peculiar seasonal effects; also to features of the sporadic E layer occurrence at Slough and of the vertical movement of the F2 layer at Huancayo.
A

LIANG, P. H., and E. V. Appleton. F_2 ionization and geomagnetic latitudes. Nature 160, 642-643 (1947).

Observations in agreement with earlier reports [E. V. Appleton (1946, 1947) and S. K. Mitra (1946)] are given and briefly discussed.
PA

LIED, F. Short-wave communication. Determination of the available frequency range. Forsvarets Forskn. Inst. Arb., 49-68 (1947). (In Norwegian.)

Discussion of ionosphere properties, height of layers and max. electron density, leads to an expression for max. frequency of electromagn. waves for a given skip distance. Damping is discussed, together with multiple reflection and atmospheric noise, and the observations at Slough, Washington, Watheroo and Huancayo are summarized. Organization of observations is described and the disturbances of solar and terrestrial-magnetic origin are discussed. A numerical example is given.
PA

LOCKWOOD, G. E. K., and L. E. Petrie. Low-latitude field aligned ionization observed by the Alouette topside sounder. Planetary and Space Science 11, 327-330 (1963).

Topside ionograms recorded near the magnetic equator show spread echoes, the ranges of which can be explained by over-dense irregularities in the ionization below the satellite. The irregularities appear to be located on a surface defined by the rotation of a magnetic field line about the magnetic axis. The similar diurnal behaviour of the equatorial anomaly and of the spread echoes suggests a common origin.
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LONDON, J., and S. Matsushita. Periodicities of the geomagnetic variation field at Huancayo, Peru. Nature 198, 374 (1963).

Recent analyses of stratospheric winds have uncovered the rather fascinating phenomenon of an equatorial stratospheric wind oscillation of approximately 26 months. Although the apparent wind oscillation seems to have its largest amplitude at about 25 km, it has been suggested by Stacey and Westcott that these stratospheric fluctuations extend to ionospheric heights. They performed a spectral analysis of the mean monthly values of the horizontal component of the geomagnetic field on magnetically quiet days, Hq, for Huancayo (12° S.), Apia (14° S.) and Alibag (19° N.). Their results indicated spectral peaks at periods of approximately 26-27

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months for Alibag and Apia but not for Huancayo. For all three stations there was also an increase of spectral density at a period of about 12 months. These results were somewhat surprising in view of the fact that at stratospheric levels the maximum amplitude of the 26-month wind fluctuation is found close to the equator and then decreases poleward. The amplitude of the annual variation, on the other hand, increases with increasing latitude. The two seem to be equal at a latitude of about 15°. To the extent that ionospheric oscillations as manifested by the oscillation of Hq are related to the stratospheric wind oscillation, one should find the more pronounced 26-month period at the lowest latitude station.

Of more immediate interest, however, is the apparent lack of any other periods in the spectral estimates of the data resulting from the analysis by Stacey and Westcott. Of particular concern is the absence of a spectral peak corresponding to a period of 6 months. We believe that this is due to the data used for their analysis of the geomagnetic field. We have re-analysed the data for Huancayo using as the basic statistic the monthly average of the daily amplitude of H for the ten quiet days of each month (1922-59). The results of our spectrum analysis are shown in Fig. 1. Spectral energy is shown corresponding to periods of about 3 months, 4 months, 6 months and 12 months, the most significant peak being that at 6 months. Nothing is evident in the neighborhood of 26 months.

Earlier analysis of these results by Matsushita showed that the periodic fluctuation of the average quiet day amplitude of H is associated with strong maxima during the equinoctial months. Huancayo is located at 12° S, where the Sun is overhead at noon approximately on November 4 and February 9. Thus, any variation in the daily amplitude of Hq which is associated with solar radiation would be expected to have dominant periods of about 3 months, 9 months and 12 months. This is not evident from Fig. 1.

The daily amplitude of H is a good indication of the intensity of the electrojet at about 100 km. The electrojet arises mainly out of the solar daily quiet current system, Sq, and has been suggested by Egedal to lie along the magnetic equator. Its intensity, according to Matsushita, is about 50 per cent larger during equinoxes than during the solstices. Thus, it is reasonable to expect a pronounced 6-month period in phenomena related to the electrojet. Also, since Huancayo lies very close to the magnetic equator one should find the amplitude variations of Hq much more pronounced at Huancayo than at higher magnetic latitude stations.
Excerpt

LONG, A. R. The distribution of electrons in the nighttime ionosphere.
J. Geophys. Res. 67, 989-997 (1962).

The mean nighttime electron density all over the world at a series of heights below the peak of the F_2 layer in the quiet ionosphere has been deduced from an analysis of ionosonde data. The results are considerably more accurate than any that have hitherto been available, since a method of analysis has been used in which the low-lying ionization, corresponding to a plasma frequency below the lowest frequency for which echoes are observed, is taken into account. A number of independent theoretical papers published in the recent past predicted that the ionization in the nighttime ionosphere would assume what is now known as an 'α-Chapman' distribution. The results of the survey presented here show that the experimental observations of the electron density-height profiles are in remarkably close agreement with these predictions. The observed form of the variation of the electron density at fixed heights with latitude at night shows little or no seasonal effects and differs considerably from the daytime form. These latitude distributions remain quantitatively unexplained.
A

LOWAN, A. N. On the cooling of the upper atmosphere after sunset.
J. Geophys. Res. 60, 421-429 (1955).

The cooling of the "upper atmosphere" (region between the altitude h_0 = 100 km and the altitude h_1 = 380 km) after sunset was investigated under the assumptions that (a) the temperature at the altitude h_0 is constant and equals 240° K, (b) the temperature gradient at the altitude h_1 is equal to zero, and (c) the process of heat transfer takes place solely by conduction. Assumed initial temperature is that given by the Rocket Panel, ranging from 240° K at altitude h_0 to 1250° K at altitude h_1. For the sake of simplicity, thermal conductivity K and specific heat c were assumed constant and dependence of density ρ on temperature was ignored, the differential equation of heat conduction being solved numerically on the assumption that the density ρ and, therefore, the thermal diffusivity $\alpha = K/c\rho$ varies with altitude but is independent of time, the variation of ρ with altitude being that given by the Rocket Panel. The computations revealed that after 2-1/2 hours the temperature has not changed at altitudes below 160 km, and that the maximum drop at altitude h_1 is 440° K. From the computed temperatures at the $t = 2^h$ (2 hours), the densities were computed from formula (2) below. Computations revealed that a certain settling of the atmosphere takes place,

the densities at time t = 2^h being larger than at time t = 0 in some region, and correspondingly lower at altitudes above the upper limit of this region. Analysis of the ion density led to the conclusion that there is an appreciable increase of the ion density in the F-layer in spite of the recombination of ions which takes place after sunset.
A

LUCAS, I. The conductivity of the ionosphere and geomagnetic variations. Naturwissenschaften 40, 239 (1953). (In German.)

Outlines an explanation for the large lunar magnetic variations observed at stations near the magnetic equator and also for the narrow zone of high conductivity (about ±7° wide) about this equator.
PA

LUNG, H. L. Seasonal variation of world-wide F2 ionization for noon and midnight hours. J. Geophys. Res. 54, 177-179 (1949).

From a study of F2 ionization for each month during the two years 1946 and 1947, it is found that for the noon hours there is a definite dip at the geomagnetic equator with a maximum on each side similar to the curves published by Appleton and Liang for the equinoctial months. Further, there is an indication of a second maximum at about 50° geomagnetic latitude. The midnight curves show only one maximum, which closely follows the solar declination. It is suggested that the midnight ionization provides a better criterion for the study of F2 seasonal variation than noon-hour values.

LYON, A. J., N. J. Skinner, and R. W. Wright, Equatorial spread-F and magnetic activity, Nature 181, 1724-1725 (1958).

It is well known that the ionospheric spread-F condition is extremely common at night in equatorial regions. At Ibadan, Nigeria (latitude 7 1/2° N.), this has been especially so during the past 2 1/2 years of high sunspot activity. It is believed that the same irregularities which produce the wide spread of scattered echoes from the F-region are also responsible for the scintillations of radio stars and perhaps for the rapid 'flutter' fading often observed in shortwave radio reception in equatorial regions.

We have previously stated that there is a tendency—especially in the winter months—for the frequency of occurrence of equatorial spread-F to be substantially reduced during periods of magnetic activity. This inverse correlation—all the more remarkable since it is the precise contrary of what is observed in temperate latitudes—has also been more marked in the past two years or so and has now been observed in all seasons.

During the current high phase of the sunspot cycle the frequency of occurrence of spread-F at Ibadan in magnetically quiet periods has been almost 100 percent. Of the 120 international quiet days of 1956 and 1957 there were only four days when spread-F was not present for at least half the night and none when it was absent altogether.

During periods of magnetic disturbance, however, the incidence of spread-F is decisively reduced. This is illustrated in Fig. 1, where the percentage occurrence of spread-F, ϕ, is plotted against the month of the year, (a) for the five international quiet days and (b) for the five international disturbed days in each month. The graphs show the mean variations for the two years 1956-57. ϕ is defined as the percentage of hours between 20h. and 05h. (beginning on the evening of the day in question) when spread-F was sufficiently strong tomake the critical frequency f_0F2 either illegible or at least doubtful (symbol UF) in the sense defined by international agreement (namely, with uncertainty greater than ± 2 percent). As Fig. 1 shows, the reduction in the incidence of spread-F on magnetically disturbed days, although occurring in all seasons, is greatest in (the southern) winter and equinox and least in summer.

To illustrate the contrast between equatorial and temperate stations we have plotted in Fig. 2 data for a number of stations for the month of September 1957, which, as is well known, was a record month for magnetic activity. The quantities plotted are values of the daily magnetic activity index, A_p, and of ϕ, the frequency of occurrence of spread-F defined above. With few exceptions the four periods of intense magnetic activity are also periods of little or no spread-F at the three equatorial stations, Ibadan, Singapore and Binza, while spread-F is almost always present at these stations during the intervening relatively quiet periods. At the two temperate stations, Slough and Lindau, the precise opposite occurs, spread-F appearing during the periods of magnetic activity, and not otherwise.

At the two stations of intermediate latitude, Karavia and Johannesburg, the incidence of spread-F is much less than at the other five stations, but in the first case the correlation is clearly of equatorial type (with magnetic activity inhibiting spread-F) and in the second case it is clearly of temperate type (magnetic activity associated with spread-F). The transition from equatorial to temperate spread-F would seem, therefore, to occur at some latitude between those of Karavia and Johannesburg—say, at about 20° S. (geographical latitude) or about 35° S. (magnetic latitude).

It may be noted in passing that the inverse correlation between equatorial spread-F and magnetic activity is also observed in years of sunspot minimum, though not always with the same consistency. A fuller discussion of this phenomenon and of possible explanations for it will be published elsewhere.

A

LYON, A. J., N. J. Skinner, and R. W. H. Wright. The belt of equatorial spread-F. J. Atmos. Terrest. Phys. 19, 145-159 (1960).

The morphology of the belt of equatorial spread-F at sunspot maximum is investigated, using IGY data, for magnetically quiet and magnetically disturbed conditions respectively. The belt is found to extend from about 30° S to 30° N in magnetic latitude and to have a region of very high incidence, exceeding 90 percent for the early part of the night, about 20° wide in latitude and centred on the dip equator. In Africa and India there is little seasonal variation in quiet-day incidence, but a marked seasonal variation occurs in the American zone where there is a pronounced minimum in local winter. Throughout the whole belt from 30° S to 30° N there is a strong inverse correlation between spread-F incidence and magnetic activity. Moreover the post-sunset rise of the base of the layer, which usually precedes the onset of spread-F shows a marked positive correlation with spread-F incidence within the belt. No existing theory seems adequate to account for all of these facts but it seems likely that hydromagnetic disturbances are involved.

A

LYON, A. J., and N. J. Skinner. Equatorial spread-F and F-layer heights. Nature 187, 1086-1088 (1960).

Earlier work on the correlation between the occurrence of spread-F and magnetic disturbance (Abstr. 7627 of 1958) has been extended to cover a twelve month period during the IGY, using data for sixty ionospheric stations. The data are divided between three seasons in two zones of longitude, and the results for these are broadly similar, with differences of detail. Within an equatorial belt (between magnetic latitudes ±20°) the occurrence of spread-F is reduced during magnetic disturbance; but at

higher latitudes, the phenomena are positively correlated, the transition occurring near magnetic latitudes ±30°. Studies are also made of the greatest value attained, during the six hours following sunset, by the virtual height h'F of the F-layer. The variations of this quantity with magnetic latitude closely resemble the distributions of spread-F incidence. The relation to theories of spread-F is briefly discussed.
PA

LYON, A. J., N. J. Skinner, and R. W. Wright The geomorphology of equatorial spread-F. IN: Beynon, W. J. G., ed. Some Ionospheric Results Obtained During the IGY, Proc. Symposium URSI/AGI Commision, Brussels, Sep. 1959, 153-157 (Elsevier Publishing Co., New York, 1960).

The authors have recently shown that spread-F in equatorial regions has the characteristics (a) that it is regularly present on magnetically quiet days and (b) that it is markedly inhibited on magnetically disturbed days. As is well known the reverse correlation is observed in higher latitudes, spread-F being most common on magnetically disturbed days. These effects were demonstrated with reference to the unusually disturbed month of September, 1957, and for a small number of stations only. In the present paper data have been examined for a twelve month period of the IGY (November, 1957, to October, 1958), and for almost all the stations in low to medium latitudes which operated during the IGY.
Excerpt

LYON, A. J., N. J. Skinner, and R. W. Wright. Preliminary results of horizontal drift measurements in the F layer near the magnetic equator. IN: Beynon, W. J. G. ed. Some Ionospheric Results Obtained during IGY, Proc. Symposium URSI/AGI Brussels, Sept. 1959, 333-337 (Elsevier Publishing Co., New York, 1960).

Observations have been made on the drift of irregularities in the ionosphere at Ibadan since about 1956. During the IGY these measurements were established on the internationally agreed programme. We present below a summary of the preliminary results of this programme.

Ibadan is situated close to the magnetic equator, having a magnetic latitude of approximately 3° S and observations on the irregularities in the ionosphere are important from two aspects, firstly, the shape of the irregularities and secondly the magnitude and direction of the drift. The records obtained at Ibadan are produced by the normal spaced receiver technique. Receiving aerials are situated approximately 100 metres to the magnetic North, South, and West of the transmitting aerial, and the received signal recorded on one display tube which is photographed on

35 mm film. Measurements of the F layer were made at 5.7 Mc/s throughout the 24 hours, and also on 2.4 Mc/s during the night.
Excerpt

LYON, A. J., N. J. Skinner, and R. W. Wright. Equatorial spread-F at Ibadan, Nigeria. J. Atmos. Terrest. Phys. 21, 100-119 (1961).

The characteristics of equatorial spread-F at Ibadan (magnetic latitude 3° S) are investigated including nocturnal, seasonal, solar-cycle and magnetic disturbance variations; and all of these are found to show marked correlations with corresponding changes in the height of the layer. For example, spreading begins shortly after the evening rise in the layer, and becomes less intense and more restricted to the higher frequencies as the layer descends later in the night. Also at Ibadan spread-F incidence on quiet days is found to increase with solar activity; and this corresponds to a marked increase in the evening rise of the layer as the solar cycle advances. A possible interpretation of these and earlier results is that the irregularities responsible for spread-F are due to hydro-magnetic disturbances which are increasingly attenuated at lower heights.
A

LYON, A. J. and (comment by) H. Rishbeth. Horizontal diffusion and the geomagnetic anomaly in the equatorial F-region. Nature 193, 55-56 (1962).

Using orthogonal coordinates x, a and z, where x is the distance along a line of force measured from a point vertically above the equator at a distance a from the center of the Earth the author derives an expression for the rate of increase of electron density due to diffusion. Ignoring one term which is small at high latitudes it is shown that this expression is equivalent to Ferraro's equation for the case of vertical diffusion. By assuming $\partial^2 N/\partial X^2 = 0$, where N is the electron density, at the equator a possible explanation of the geomagnetic anomaly in the equatorial F-region is proposed. Rishbeth in his reply questions the truth of this assumption and goes on to suggest that the equatorial anomaly may be explained by an extension to equatorial regions of theoretical studies of an idealized F-region controlled by production, loss and diffusion similar to previous studies which have been applied to higher latitudes.
MGA

LYON, A. J. The geomagnetic anomaly. IN: Proc. International Conference on the Ionosphere, London, July 1962, 88-93. The institute of Physics and the Physical Society, London, 1962).

Presentation of the variations of the noon values of f_0F_2 and $M(3,000)F_2$ with magnetic latitude, obtained on quiet days in each of three seasons during the IGY, for three longitude zones over the latitude range of ±50°. The conversion of $M(3,000)F_2$ to h_mF_2 is investigated. The variations of f_0F_2 are found to be nearly symmetrical with respect to the magnetic equator at equinox, but to exhibit a marked asymmetry in both solstices, with greater values in the winter than in the summer hemisphere, over the entire range of latitudes studied. The variations of $M(3,000)F_2$ indicate that h_m is always high over the region of the equatorial trough and, similar to f_0F_2, has an asymmetrical variation at the solstices, with lower values in the winter than in the summer hemisphere.
IAA

LYON, A. J., and L. Thomas. The F2-region equatorial anomaly in the African, American, and East Asian sectors during sunspot maximum. J. Atmos. Terrest. Phys. 25, 373-386 (1963).

A study has been made of the characteristics of the F2-region equatorial anomaly in the African, American and East Asian sectors during quiet days of the 1958 equinoxes, particular attention being given to its diurnal development. It is shown that the evening enhancement of the crests north and south of the magnetic equator occurs first on the side near to the geographic equator. An examination of the latitude variation of hmF2, derived from M(3000)F2 data, for the evening hours shows a marked asymmetry about the magnetic equator, the greater heights also occurring on the side near to the geographic equator. It is suggested that this sequence in the development of the crests, together with the height asymmetry, supports the hypothesis that they result from diffusion of ionisation along magnetic lines of force from above the magnetic equator.
A

LYON, A. J. Diffusion of ionisation in a dipole field. J. Geophys. Res. 68, 2531-2540 (1963).

An equation is derived for the rate of ambipolar diffusion along lines of force in a dipole field; its significance is discussed, especially in relation to the magnitude and effects of horizontal outward diffusion in the ionosphere near the magnetic equator. At great heights the variation of electron density with reduced height z approximates at all latitudes to $e^{-1/2\,z}$.

L

Upward electrodynamic drift at the equator can probably lead to a substantial reduction of peak electron density, owing to increased outward diffusion, as envisaged in the 'fountain theory,' but only if the drift velocity is large in relation to the ambient recombinative loss rate.

A

MAEDA, H. On the disturbance daily variations and the lunar daily variations in the F2 region of the ionosphere on the magnetic equator. J. Geomag. Geoelec. 7, 75-85 (1955).

No abstract available.

PA

MAEDA, H. Observed facts of the geomagnetic distortion in the ionosphere. Rept. Ionosphere Res. Japan 9, 59-70 (1955).

In Pt. 1, an extensive study is made on the latitude distribution and the daily variation of all ionospheric layers (F1, F1 and E) during the sunspot minimum period (1953-1954), to examine the fact of geomagnetic distortion in the ionosphere, and the harmonic components of the geomagnetic Sq variations are presented, analyzed from the data of the Second Polar Year.

N

MAEDA, H. Daily variations of the electrical conductivity of the upper atmosphere as deduced from the daily variations of geomagnetism. I. Equatorial zone. Rept. Ionosphere Res. Japan 9, 148-165 (1955).

Based on Huancayo data on daily magnetic variations. Uses method of Hasegawa to get daily variation of dynamo-region ionospheric conductivity from magnetic variations. Gives theory of analysis and results of calculations. Finds nighttime conductivity about 1/10 noon conductivity. Says zero level of daily magnetic variations lower than daily mean value by about 45% of diurnal amplitude. Hence, westward maximum current intensity near midnight about 1/10 of eastward maximum intensity near noon for Sq, but former near sunset about 1/5 of latter near noon for Sd. Finds diurnal amplitude of electric field very large compared with semidiurnal amplitude. Diurnal amplitude increases slightly with increasing sunspot number, and diurnal phase lags about 15 deg (1 hr) from sunspot minimum to maximum.

M

MAEDA, H. Geomagnetic distortion of the F2 region on the magnetic equator. II. J. Geomag. Geoelec. 11, 1-5 (1959).

The daily variation of the F2 region on the magnetic equator was investigated using Huancayo data over one sunspot cycle. It was found that the type of the daily variation of f_0F2 shows a systematic change with the sunspot cycle and is fairly closely connected with the phase shift in the geomagnetic S_q variations.

PA

MAEDA, H., and M. Yamamoto. Daytime enhancement of the amplitude of geomagnetic sudden impulses in the equatorial region. Rept. Ionosphere Space Res. Japan 14, 443 (1960).

The purpose of this note is to obtain some information about geomagnetic sudden impulses (si's) in the equatorial region. The data examined here are 110 si's during the IGY at eleven stations, Honolulu, Kanoya, M'Bour, Fanning, Ibadan, Jarvis, Muntinlupa, Huancayo, Koror, Guam and Apia.

We have, by using the data at these same stations, recently studied the daily variation in amplitude of the sudden commencements (ssc's) of geomagnetic-storm and found that the daytime enhancement in the amplitude of the horizontal component of ssc's occurs at all stations in the equatorial region. Such an analysis has now also been made for si's, and its result is shown in Fig. 1 by the full lines. And, for comparison, the previous result for ssc's is illustrated in the same figure by dotted lines.

It will be seen from the figure that: (1) the daytime enhancement at equatorial stations occurs not only in the amplitude of ssc's but also in the amplitude of si's; (2) the character of the daily variation in amplitude at each equatorial station is almost the same for both ssc's and si's. These results may suggest that the si occurrences are essentially of the same mechanism as the ssc's, though there are somewhat different properties between them.

A

MAEDA, H., and M. Yamamoto. A note on daytime enhancement of the amplitude of geomagnetic-storm sudden commencements in the equatorial region. J. Geophys. Res. 65, 2538-2539 (1962).

The fact that the amplitudes of SC's at Huancayo are significantly enhanced during the daylight hours has been noted by Ferraro and Unthank [1951], Sugiura [1953] and Yumura [1954]. Moreover, Vestine [1953] and Forbush and Vestine [1955] have pointed out that such a daytime enhancement is seen not only in size of SC's but also in size of IP at Huancayo, and that the average size of SC's is greater for those days with the large diurnal variation (S_q) in H. The studies of all these authors are, however, based on data at Huancayo alone.

The purpose of this note is to consider whether such enhancements are also seen at other equatorial stations than Huancayo. The data used here are 50 SC's during the IGY, at Honolulu, Kanoya, M'Bour, Fanning, Ibadan, Jarvis, Muntinlupa, Huancayo, Koror, Guam, and Apia (see Fig. 1).

In Figure 2 are plotted the ratios of amplitude of the horizontal component of SC's at the other ten stations to those at Honolulu, for each of 50 SC's which occurred at various Greenwich times. Although the number of SC's considered here is not large enough to permit quantitative treatment of equatorial enhancement, the following general features may be seen from

Figure 2. (1) The daytime enhancement of SC's occurs at stations less than about 20° in dip, and an abnormally large amplitude appears at stations very close (within about 3° in dip) to the dip equator. (2) At stations higher than 20° in dip, no appreciable diurnal variation in SC's is seen. (3) The magnitude of SC's in the night is almost the same for all equatorial stations.

These results may suggest that the sudden commencement of geomagnetic storms consists of two parts, one of atmospheric and the other of outer-atmospheric origin. The former seems to be due to an electric current which probably flows in the S_q-current layer, as suggested by Forbush and Vestine [1955], and the latter seems to be caused in such a manner as Chapman-Ferraro model. The separation of these two parts may be possible by using nighttime values of SC's. Detailed studies of SC's, however, are now in progress, and their results will be published later.
Excerpt

MAEDA, K. Distortional characteristics of the world-wide distribution and diurnal variation of the ionospheric F2-layer associated with the geomagnetic variation. J. Geomag. Geoelec. 4, 83-93 (1952).

Treats effect of vertical motion of electrons on F2 layer analytically. Relates vertical electron velocity to density of horizontal dynamo current. Finds electron-density depression and height rise around noon at magnetic equator, longitudinal inequality of latitude distribution of noon density, and shape of daytime variation of electron density can be plausibly interpreted.
M

MAEDA, K. Geomagnetic distortion in the F2 layer. Rept. Ionosphere Res. Japan 3, 155-164 (1954).

In order to illustrate the geomagnetic distortion in the F2 layer, the following curves are presented.

1. Geomagnetic latitude distributions of seasonal average of the noon f_0F2 and h'F2 for three geomagnetic longitudes (Λ=0°, 90° & 270°, 180°). – The most remarkable features are:

(a) depression of f_0F2 near the geomagnetic equator,

(b) rise of h'F2 near the geomagnetic equator.

2. Geomagnetic latitude distributions of seasonal average of the midnight f_0F2 and h'F2.– The following are pointed out:

(a) low level of h'F2 and symmetry around the equator,

(b) low value of f_0F2 on the winter hemisphere and higher value of f_0F2 on the summer hemisphere. It seems that the time

duration from sunset to midnight controls the level of f_0F2.

3. Seasonal variation of monthly median of the noon h'F2. —The main features are:

(a) high value in the summer solstice on the middle and higher geomagnetic latitudes,

(b) one peak each in the summer and winter solstices on the low geomagnetic latitude.

4. Daytime variation of f_0F2.—The shapes of variation curves are systematically distributed on the geomagnetic latitude.

A possible interpretation of some characteristics and a discussion thereof are presented from the viewpoint of the dynamo theory on geomagnetism.

A

MAEDA, K. Geomagnetic distortion in the F2 layer. IN: Physics of the Ionosphere, 245-253 (The Physical Society, London, 1955).

The following curves are presented: (i) Geomagnetic latitude distributions of seasonal average of the noon f_0F2 and h'F2 for three geomagnetic longitudes ($\wedge$=0°, 90° and 270°, 180°). The most outstanding features are (a) depression of f_0F2 near the geomagnetic equator, (b) rise of h'F2 near the geomagnetic equator. (ii) Geomagnetic latitude distributions of seasonal average of the midnight f_0F2 and h'F2. The following are pointed out: (a) low level of h'F2 and symmetry around the equator, (b) low value of f_0F2 on the winter hemisphere and higher value of f_0F2 on the summer hemisphere. It seems that the time duration from sunset to midnight controls the level of f_0F2. (iii) Seasonal variation of monthly median of noon h'F2. The main features are (a) high value in the summer solstice on the middle and higher geomagnetic latitudes, (b) each one peaks in the summer and winter solstices on the low geomagnetic latitude. (iv) Daytime variation of f_0F2. The shapes of the variation curves are systematically distributed on the geomagnetic latitude. A discussion and a possible interpretation of some characteristics are presented from the viewpoint of the dynamo theory of geomagnetism.

PA

MAEDA, K. Theoretical study on the geomagnetic distortion in the F2 layer. Rept. Ionosphere Res. Japan 9, 71-85 (Sept. 1955).

In Pt. 2, the vertical and horizontal drifts of electrons in the F2 region are studied in connection with the geomagnetic variation and the effects of drifts on the F2 layer are treated. It is found that the geomagnetic distortion in the F2 layer can largely be interpreted by the drift.

N

MAEDA, K. I., and T. Sato. The F region during magnetic storms. Proc. IRE 47, 232-239 (1959).

The results are described of statistical investigations made in the F region during magnetic storms. The characteristics of the daily variation of the deviation from the mean critical frequency and of the height of the maximum electron density, Δf_0F2 and Δh_pF_2, respectively, are shown over the wide range of latitude from the equator to the auroral zone and for the principal seasons of the year. After a brief survey of theories to interpret the observed results, it is shown that the ionization-drift theory, which is associated with the dynamo theory, is almost satisfactory for the consistent interpretation of the various facts observed.

MAEDA, K., and T. Tsuda. Theoretical interpretation of the equatorial sporadic-E layers. Phys. Rev. Letters 11, 406-407 (Nov. 1963).

The purpose of this note is to make a theoretical explanation of the echo structure of the equatorial E_s. Up to this day, some authors have attempted to describe the formation of the equatorial E_s, e.g., from the viewpoint of two-stream plasma-wave instability, etc.

Our theoretical basis is similar to that by Simon, which is aimed at the instability analysis of weakly ionized plasmas. Particular modifications are done so as to make Simon's method applicable to the present ionospheric model.

A

MAINSTONE, J. S., and R. W. E. McNicol. Micropulsation studies at Brisbane, Queensland. I. Pearl pulsations and 'screamers.' IN: Proc. International Conference on the Ionosphere, London 1962 163-168 (The Institute of Physics and The Physical Society, London 1963).

Frequency-time plots of micropulsations in the 0.5 c/s region, recorded at Brisbane (35° S geomagnetic latitude), exhibit a characteristic striped pattern. This pattern consists of rapid upward frequency sweeps over a limited, well-defined range. The modulated wave form of pearl pulsations may be explained in terms of this structure. The time between successive frequency sweeps is constant (160-170 sec), but the slope of the sweep is variable.

A characteristic train of pulsations with frequencies generally in the 1 c/s range, lasting for periods of up to 5 or 6 hours, constitutes a 'screamer'. Screamers may consist of several bursts of activity whose average frequency rises appreciably from one burst to the next, but within each of which the frequency falls.

Pearls with a recurrence period of 145 sec have been reported from Canada (60° N geomagnetic latitude); the period found in Brisbane is ~160 sec. A disturbance originating in the auroral zone, and propagated as hydromagnetic waves towards the equator, may account for this agreement over a considerable range of latitudes.

A

MANNING, L. A. Bibliography of the Ionosphere (Stanford University Press, Stanford, Calif. 1962).

In 1947 I prepared a report entitled "A Survey of the Literature of the Ionosphere" for the Air Materiel Command, Wright Field; in 1955 a second edition of the survey appeared under the sponsorship of the Air Force Cambridge Research Center. The present volume is a revision and extension of these earlier reports, and has been prepared under Contract AF19(604)-6194 with the Air Force Cambridge Research Laboratory. It includes most of the abstracts of the earlier surveys in revised form, together with a considerably larger number of abstracts describing papers published from 1955 through 1960; in all, nearly 4,000 papers are listed.

In the present volume are listed the great majority of papers on the ionosphere published in recognized periodical journals through 1960. An original abstract summarizes my views on the contents of each of these papers. The period covered goes back to the important pioneer studies of 1925, and in some cases to earlier work. Articles in symposium volumes, books, or technical reports have not been included. A code gives the institutional affiliation of the authors, and a subject index is included as a guide to the contents of the papers.

The ionosphere may be broadly described as the ionized part of the atmosphere; its lower boundary lies at a height of 40 to 60 km, its upper boundary as high as 60,000 km. Papers have been included in the survey if they dealt with ionospheric radio propagation, radio studies of the ionosphere, or physics of the ionosphere important to radio studies. Examples of such topics are radio studies of the aurora, rocket studies of the upper atmosphere, eclipse effects on radio propagation, recombination and diffusion processes in the F region, solar effects on the ionosphere, and the formation of ionized meteor trails. Examples of topics excluded are many

studies of the geomagnetic field, of the aurora by visual and spectroscopic methods, of solar radio astronomy, and of the design of communications systems. Ionospheric papers were located in over 220 scientific journals by examining tables of contents. However, it is interesting that fully one-third of the literature has appeared in three leading journals and much of the remainder in another dozen periodicals. Special supplements and other matter not available by regular journal subscription have been consulted only in special instances.

Within the limits described above, the great majority of papers through 1960 have been included. However, because of late acquisition, or for similar practical reasons, some papers had to be left out. Unfortunately, several authors (for instance M. Haubert) have been hit rather harder than most by this forced neglect, and to them goes an apology. Wherever possible, articles in languages other than English were translated and abstracted, except for articles in Japanese--no effort was made to translate these. However, since most Japanese papers appear also in English translations, the coverage of Japanese work is reasonably adequate.
A

MAPLE, E., W. A. Bowen, and S. F. Singer. Evidence for ionosphere currents from rocket experiments near the geomagnetic equator. Phys. Rev. 82, 957-958 (1951).

Launched 2 Aerobee rockets off coast of Peru at geomagnetic latitude -1 deg; 2nd flight showed magnetic-field decreases 4 mgauss at height of 93 to 105 km. Attribute to current layer.
M

MARASIGAN, V. Bifurcations in the F-region at Baguio, 1952-1957. J. Atmos. Terrest. Phys. 13, 26-31 (1958).

A 5-year statistical survey of bifurcations in the F-region at Baguio is presented and analysed in the light of a parametric mechanism of the v-R relations of the F1- and F2-layers. The conclusion is reached that two of the features of bifurcation-statistics are mainly due to variations in layer heights and thicknesses with season and solar activity respectively.
A

MARASIGAN, V. Spread-F in Baguio through half a solar cycle. J. Atmos. Terrest. Phys. 18, 43-47 (1960).

A 6-year statistical survey is made of spread-F occurrence in Baguio. An attempt is made to explain the observed periodicity by the randomness of density-distribution introduced by the predominance of collision-detachment and by the random downward velocities.
A

MARASIGAN, V. Geomagnetic sunspot influences on spread-F in Baguio. J. Atmos. Terrest. Phys. 18, 257-258 (1960).

It has been shown (Lyon, Skinner and Wright, 1958) that magnetic activity tends to reduce the frequency of occurrence of spread-F at Ibadan, Nigeria. This tendency is also observed at Baguio, Philippines (latitude 16.4° N).

A count was made of the presence of spread-F on Baguio ionograms, the norm being a spread-echo intensity sufficient to make the scaling of (M3000)F2 uncertain. The ionograms studied were the hourly ionograms from 1900 to 0800 hours local time, for five international quiet days, for five international disturbed days, and for all days, of each of the 72 months from January 1953 to December 1958. The counts were transformed to percentages and averaged for each of the two 3-year groups, 1953-1955 being years of low sunspot count and 1956-1958 of high sunspot count. The results are illustrated in Fig. 1.

It is seen (1) that the tendency of magnetic activity to reduce spread-F occurrence is greater and more consistent in years of high sunspot count than in years of low sunspot count, and (2) that the pattern of seasonal variation of spread-F occurrence changes with the solar cycle independently of magnetic activity.
A

MARIANI, F. The worldwide distribution of the F2 layer electron density: Seasonal and non-seasonal variations and correlations with solar activity. Nuovo Climento 12, 218-240 (1959).

The worldwide behaviour of the twelve-month period (seasonal and non-seasonal) variation of the maximum electron density N in the F2 layer appears noticeably different at noon and at midnight. In each case, it is controlled by the geomagnetic field and by the solar activity but, whilst at noon it shows large asymmetric features in the two hemispheres, at midnight,

on the other hand, it is fairly symmetrical. It is not possible to account for the experimental results by assuming some external source of radiation producing non-seasonal effects. One is led to assume some terrestrial cause of asymmetry: for example, some effect of general circulation in the upper atmosphere. With respect to the correlation of electron density with solar activity, there appears again some noticeable asymmetry in the two hemispheres; in particular, the northern hemisphere appears more influenced by the solar hydrogen filaments, especially for increasing latitude. The explanation of these asymmetries, in terms of some direct influence of the sun, is also puzzling, so that, in this case, one is led to think of some more or less unknown effect of solar corpuscular (or electromagnetic) radiation on the upper atmosphere, for example on its movements or its conductivity. At the present stage of our knowledge, we cannot exclude the possibility of a similar cause for both the asymmetries of the twelve-month period variation and of the correlations with solar activity. Further observational evidence is required.
A

MARIANI, F. Pitch-angle distribution of the photoelectrons and origin of the geomagnetic anomaly in the F2 layer. J. Geophys. Res. 69, 556-560 (1964).

A major anomaly of the F region is the 'equatorial' or 'geomagnetic' anomaly, which consists of the pronounced minimum of f_0F2 on the geomagnetic equator and two maximums near 20° north and south geomagnetic latitude, at meridian hours and in the afternoon, in every season. A recent theoretical approach [Goldberg and Schmerling, 1963] favors the hypothesis that a diffusion process from the equator along the magnetic lines of force can produce the enhancement of f_0F_2 in both hemispheres. However, it has been suggested that this process alone is not sufficient to explain completely the observed anomaly [Rishbeth et al., 1963].

It is the purpose of this letter to present in some detail one simple mechanism that also may play a role in the explanation of the anomaly. This mechanism is based on a detailed analysis of the physical processes that the photoelectrons undergo in the upper atmosphere.
Excerpt

MARSH, D. P. Observations relating to the distance scale for motions of electrojet-electron precipitation regions in the auroral zone. J. Geophys. Res. 68, 4167-4174 (1963).

From a comparison of X-ray, ionospheric absorption, and geomagnetic observations during an intense electron precipitation event in the auroral zone, it is shown that the distance scale for motions of electrojet-electron precipitation regions is smaller than previously considered. This requires a downward revision of the correction factors for currents induced in the earth by ionospheric current systems.
A

MARTYN, D. F. Dispersion and absorption curves for radio wave propagation in the ionosphere according to the magneto-ionic theory. Phil. Mag. 19, 376-388 (1935).

It is now well established that the earth's magnetic field exerts considerable influence on the propagation of wireless waves in the upper atmosphere. In particular the magneto-ionic theory developed by Appleton, Breit, Goldstein, and Hartree has achieved a number of notable successes in the interpretation of propagation phenomena. When the effects of collisions between the electrons and molecules are taken into account a frictional term is introduced into the equations of motion of the electrons, and the resulting equations for the refractive index of the medium become complex. The method of introducing this frictional term has been given by Baker and Green and by Appleton and Naismith. A good discussion of the resulting complex equations for the refractive indices and polarizations of the basic modes of propagation has been given by Mary Taylor, who has also published a number of curves illustrating the variations of these quantities with increasing ionization density N for several typical wave frequencies (p) and collision frequencies (v), and for the particular angle made by a vertically downcoming wave with the positive direction of the earth's magnetic field at Slough, England. The derivation of such curves normally involves much labour. At the suggestion of the author this aspect has been investigated by Prof. V. A. Bailey, who has succeeded in developing an elegant graphical method of making such a survey, using the device of conformal representation.
Excerpt

MARTYN, D. F. The propagation of medium radio waves in the ionosphere. Proc. Phys. Soc. 47, 323-339 (1935).

All the available measurements of sky-wave intensities at medium frequencies are collated and expressed as field-strength, distance curves for six typical wavelengths and for distances from 25 to 1000 km. It is shown how this material may be used for the determination of the non-fading radii of broadcasting emitters over country of any effective conductivity. From the observational material an empirical expression for the reflection coefficient of the lower E layer of the ionosphere is derived. It is shown that the observations are incompatible with the existence of a linear or parabolic gradient of ionization in this layer. This incompatibility is not removed by the assumption of an absorbing or D region below the E layer, or by consideration of the variation with height of the collision frequency v of an electron with the air molecules in the E layer. It is found that the observations can be fully explained if the gradient of ionization is given by the exponential form $N = \epsilon^{h}$, where h is the height in km. above the region where ionization first becomes appreciable. This gradient also gives rise to equivalent heights which are in agreement with experience. It is found that v has a value of 10^6 collisions per second at a height of 90 km., in close agreement with Chapman's recent estimate. It is shown that the conclusions reached are not affected by use of the ray methods of geometrical optics, or by neglect of the influence of the earth's magnetic field.
A

MARTYN, D. F., Atmospheric tides in the ionosphere. I. Solar tides in the F2 region. Proc. Roy. Soc. A 189, 241-260 (1947).

A theory, based on solar tides, is advanced to explain the anomalous seasonal, diurnal and geographical variations of F2 region ionization. It is shown that the horizontal winds due to these tides must cause electrons to move along the lines of the earth's magnetic field. The resultant motion has a vertical component. Account is taken of polarization of the medium by the 'dynamo' electric forces. Owing to viscosity the vertical motion decreases upwards in the F_2 region. Application of the equation of continuity shows that the F_2 region becomes greatly distorted. A 'longitude effect' is found to arise by reason of the asymmetry of the earth's magnetic field. The theory is used to explain the high F_2, ionization densities found in low latitudes, and the high values of h'_{F2} at noon near the equator. It is also used to explain the afternoon and night-time increases in ionization found at certain locations. It is suggested that the effective recombination coefficient in F_2 is much lower than the generally accepted values. It is shown that Appleton & Weekes's evidence of lunar tidal effects in the E region does not conflict with the 'dynamo' theory of magnetic variations or with Pekeris's calculations.

Observational evidence of the existence of solar tides in the F_2 region is presented.
A

MARTYN, D. F. Atmospheric tides in the ionosphere. II. Lunar tidal variations in the F region near the magnetic equator. Proc. Roy. Soc. A 190, 273-288 (1947).

Three years' data for the heights and critical frequencies of the F_1 and F_2 regions at Huancayo, Peru, are examined for lunar tides. Semi-diurnal lunar tides are found in all quantities save f^0F_1. It is found that the lunar variation in the F_2 region depends on solar time in both phase and amplitude. At certain solar epochs it attains very large amplitudes, up to 60 km in $h_{F_2}{}^{max}$ and 28% in f^0F_2. The theory of these variations is further developed.
PA

MARTYN, D. F. Atmospheric tides in the ionosphere. III. Lunar tidal variations at Canberra. Proc. Roy. Soc. A 194, 429-444 (1948).

A study has been made of the lunar variations in heights and critical frequencies of the E, F_1 and F_2 regions above Canberra, Australia. Semi-diurnal lunar variations have been found in all these quantities, and the harmonic coefficients determined. From the study of these it is concluded: (a) that ionospheric lunar variations are caused by ionic drift under the action of the 'dynamo' electric forces, and not by simple tidal rise and fall of isobaric surfaces; (b) that the lunar magnetic variations are not produced in the E, F_1 or F_2 regions.
A

MARTYN, D. F. Atmospheric tides in the ionosphere. IV. Studies of the solar tide, and the location of the regions producing the diurnal magnetic variations. Proc. Roy. Soc. A 194, 445-463 (1948).

Solar tidal effects are sought in ionospheric data from representative latitudes. They are found in the E, F_1 and F_2 regions. For the F_2 region the seasonal semi-diurnal harmonics arising from P_3^2 are comparable with those from P_2^2. The amplitudes and phases of these harmonics are determined, and they are used to interpret the global distribution of F_2 ionization. Evidence is found that the lunar magnetic variation is produced mainly by currents in the D region of the ionosphere, but is opposed by the corresponding currents in the E and F_1 regions. This finding is submitted to an independent test, using McNish's evidence of the effects of solar flares on the magnetic variation.
A

MARTYN, D. F. Lunar variations in the principal ionospheric regions. Nature 163, 34-36 (1949).

It has recently been found that semi-diurnal lunar variations are derivable from the routine measurements made at ionospheric observatories. These variations are found not only in the heights of all the principal ionospheric regions, but also in the maximum electron densities of the F_2 region. Near the magnetic equator they are found to be very large indeed, the height variations being at certain times some fifty times greater than the already large variations previously found by Appleton and Weekes in the E region.
Excerpt

MARTYN, D. F. Daily magnetic variations near the equators. Nature 163, 685-686 (1949).

The establishment of the observatory at Huancayo, Peru, near the magnetic equator, led to the discovery of daily magnetic variations, both solar and lunar, approximately twice as great as those previously found in other tropical regions. McNish has sought to explain this anomaly by qualitatively modifying the Balfour Steward-Schuster 'dynamo' theory to allow for the non-coincidence of the earth's magnetic and geographic axes. According to McNish, enhanced magnetic variations should occur in the areas between the magnetic and geographic equators. On the other hand, Egedal and Chapman have recently put forward data from tropical regions which appear to show that the distribution of the phenomenon is more complex than could be explained by McNish's suggestion.
Excerpt

MARTYN, D. F. Symposium on dynamic characteristics of the ionosphere. IN: Proc. Conference on Ionospheric Physics, State College, Pa., 24-27 July 1950. (See also comments by M. H. Johnson, A. G., and McNish.)

The hydrodynamics of the ionosphere is discussed. Air becomes very viscous at F-region heights and above. This implies rotation and accompanying mathematical complications. Diffusion is considered. The importance of eddy diffusion is noted; such eddies may be damped because of appreciable viscosity. A continuity equation for the ionosphere is presented.

Gravitational effects of sun and moon (tides) are discussed; tidal motion in the ionosphere is more violent than that of earthly (incompressible) oceans. Circulations set up by thermal effects of the sun are indistinguishable from gravitational ones.

Atmospheric resonance at about 11 hr. 56 min. causes solar effects at ground level about 15 times larger than those produced by the moon due to resonance effects.

Mathematical models that do not apply but have clouded the issue are: full adiabatic gradient and an atmosphere of constant temperature with isothermal expansions (i.e., the expansion due to tidal influence takes place isothermally). These are the only two cases that are relatively simple and give motion falling off exponentially with height, and energy flow is largely concentrated near ground. Since the atmosphere has a marked temperature gradient and expansions take place adiabatically, one must expect different cicumstances to arise (i.e., bringing of rotational components).

Tides may be the dominating effect in upper atmosphere (due to amplification of ground level motions caused by heating and gravitational forces).

When one puts in the magnetic field of earth, the majority of air motions are horizontal, because the ratio of vertical to horizontal velocities must compare with the ratio of the height of the ionosphere and the radius of the earth (need continuity of flow in individual postulated cells).

I will comment, that the layer in which you would expect a phase change at 35 degrees, Mr. McNish, is a layer which is a fundamental producer of tidal action. In other words we find in the ionosphere that that appears to be the E-region or something very near to it, and that is where we look for this phase change at 35 degrees. On the other hand we find that in the F_2-region all over the globe from the pole to the equator, leaving out the magnetic equator, the phase is approximately the same until we get very near to the magnetic equator, when there is very definitely an anomoly. Now what I have tended to do, what we have done in Australia anyhow, and what I mentioned to Dr. Johnson yesterday, is to try and forget for the moment the complexities in that zone near the magnetic equator. It is quite a small zone and a very serious anomaly, but let us get the rest of the picture right first and then deal with the anomalies which undoubtedly occur there. Now, we are working on these particular anomalies as well, and there is one very interesting feature about them and that is this. I mentioned before that all regions are linked by lines of magnetic force, but when we come to the magnetic equator the line of force which joins the F_2-region to a lower region runs as shown by the dashed line in figure 12 and there is a zone indicated by the shaded portion which is quite anomalous. If you are taking the distribution of currents over the whole sphere, you find that everything is continous except for this zone where there is no linkage between the lower region and the F_2-region. Now in any theory whatever, that introduces profound discontinuities. Dr. Baker is examining that at the moment from the point of view of both the ionosphere theory and of magnetic variation theory, and one of his preliminary findings which he has asked me to announce at Zurich is that there is a very strong meridianal current flowing near this zone as shown. Now how these meridianal currents effect the ionization density is another matter which I think would lead us rather away from dynamics to discuss at the moment, but at any

rate I want to point out that we would agree on the story very thoroughly about the fact that the lunar tide in the F-region at Huancayo is anomalous over a certain zone and that the reason for that is not yet clear.
Excerpt

MARTYN, D. F. The morphology of the ionospheric variations associated with magnetic disturbance. I. Variations at moderately low latitudes. Proc. Roy. Soc. A 218, 1-18 (1953).

A study is made of the variations in the heights and densities of the ionospheric regions, particularly the F_2 region, during magnetic disturbance. Data from three observatories in moderate latitudes, namely Watheroo, Canberra, and Washington are used, and the disturbance variations in both local time and storm time are exhibited. The former variations are found to be mainly diurnal in type; the latter are appreciable for about three days after the commencement of the magnetic storm. The initial shape of the curve of storm-time variation depends markedly on the local time of commencement of the magnetic storm.

A theory of these variations is developed, according to which all ionospheric disturbance variations are due to the effect of an electrostatic field which is developed in the auroral zone, and spreads over the earth through the ionosphere in such a way as to produce the current responsible for the disturbance daily magnetic variations. The interaction between these currents and the earth's magnetic field produces a drift in the ionization of the ionospheric regions. This drift is held to be directly responsible for the observed ionospheric variations. Thus all ionospheric disturbance variations, and also the world-wide disturbance magnetic variations, are attributed to a single cause, the electrostatic field produced by the intense impressed current system in the auroral zones.
A

MARTYN, D. F. Interpretation of observed F2 'winds' as ionization drifts associated with the magnetic variations. IN: Physics of the Ionosphere, 163-165 (Physical Society, London 1955).

It is shown that the diurnal, seasonal diurnal, and magnetic disturbance diurnal 'winds' in the F2 region are consistent, in phase, amplitude, and spatial distribution, with the view that they are drifts of (neutral) ionization produced by a potential (electric) field in the main conducting region of the ionosphere. This field, which is communicated to the F2 region along the highly conducting lines of magnetic force, is that which is now known to be associated with the magnetic quiet day and disturbance variations, when allowance is made for the Hall conductivity of the main conducting region.
A

MARTYN, D. F. Theory of height and ionization density changes at the maximum of a Chapman-like region, taking account of ion production, decay, diffusion, and tidal drift. IN: Physics of the Ionosphere, 254-259 (The Physical Society, London, 1955).

Formulae are derived for $\partial z_m/\partial t$ and $\partial N_m/\partial t$ (the time variations of the height and ionization density respectively, at the maximum of a Chapman-like region), taking account of ionization production, decay, diffusion, vertical drift, and of height gradient in each of these influences. It is shown how the height gradient of drift appears to account adequately for main features of the geomagnetic anomalies in the world contours of z_m and N_m; the anomalies are further enhanced by the virtual disappearance of vertical diffusion of ionization at the magnetic equator.
A

MARTYN, D. F. Geomagnetic anomalies of the F2 region and their interpretation. IN: Physics of the Ionosphere 260-264 (The Physical Society, London, 1955).

Curves are given showing the world distribution of f_0F2 at two sunspot epochs and for three seasons. The anomalies thus revealed are then classified. The dynamo theory of the magnetic variations, as developed by Baker and Martyn, is used to link the observed F2 morphology with the morphology of the magnetic variations at both quiet and disturbed times. A quantitative interpretation is made of the main F2 anomalies such as the morning rise and evening fall in F2 height, the symmetry about the geomagnetic equator, and the anomalous diurnal variation of F2 height and density in the anomalous equatorial zones.
A

MARTYN, D. F. Processes controlling ionization distribution in the F2 region of the ionosphere. Austral. J. Phys. 9, 161-165 (1956).

It has been known for more than 20 years that the morphology of the principal (F_2) region of the ionosphere is complex, and inexplicable in terms only of solar ionizing radiation and recombination. The hypothesis was advanced (Martyn 1947) that movement, and especially vertical movement, of F_2 ionization was the main reason why the morphology of this region differed so profoundly from that of the lower regions E and F_1, which conform closely with Chapman's well-known theory. A principal cause of movement of F_2 ionization was held to be the drift occasioned by the electrodynamic forces and winds associated with the ionospheric electric current systems whose existence is manifested by the daily magnetic variations at the ground. There is now considerable evidence, both

theoretical and observational, to show that this view may be essentially correct.
A

MARTYN, D. F. The normal F region of the ionosphere. Proc. IRE 47, 147-155 (1959).

The global morphologies of the F_1 and F_2 regions at magnetically quiet times are reviewed, and attention also is given to the sunspot-cycle variations. The physical conditions, temperature, pressure, recombination coefficients, and collision frequencies are reassessed in the light of recent studies of rocket and satellite results and of diffusion. The theory of the F region is reviewed with special attention to Bradbury's hypothesis and to the effects of transport of ionization.

Also considered are the morphology of "spread-F" and radio star scintillation phenomena. A theory of the latter is outlined, and it is shown that the undersurface of the F region is unstable at times of upward drift, which appear to be the times when such phenomena are prominent.
A

MARTYN, D. F. Sporadic E-region ionization, "spread-F", and the twinkling of radio stars. Nature 183, 1382-1383 (1959).

All these phenomena reveal the presence in the ionosphere of inhomogeneities in electron density of thickness some kilometres or less, the frequency of occurrence of which shows well-marked diurnal, seasonal, and geographical distributions, as well as correlation with geomagnetic activity. In the auroral zones they may be mainly due to ionization (in columns and sheets) produced by direct bombardment of the particles producing aurorae. However, aurorae occur rarely at moderate or low latitudes, where all these phenomena happen daily; in fact, at such latitudes the correlation of the latter with magnetic activity tends to be rather strongly negative.

A clue to the origin of these phenomena at nonauroral latitudes may lie in the fact that they appear to have one common feature: they occur most frequently or most intensely at times when the ionization of the relevant matrix region (E or F) is moving upwards under the influence of the electrodynamic forces associated with the ionospheric electric current systems responsible for the solar, lunar or disturbance geomagnetic variations. For example, equatorial sporadic E-region ionization is a maximum near noon, when the equatorial electrojet current is a maximum eastwards, and at 8-9 hr. lunar time, when the lunar electrojet has a similar maximum. Again, the occasional reductions of the equatorial daytime (eastward) electrojet which are associated with geomagnetic disturbance are accompanied by a corresponding reduction in equatorial sporadic E-region ionization.

Some years ago it was suggested that such E-region ionization was essentially due to vertical movements, and the phenomena associated with the drifting of an inhomogeneity in an otherwise uniformly ionized medium were afterwards examined. In a region of negligible Hall conductivity (such as the F2-region) the effects are simple. A long cylinder of electron density $N + \Delta N$ aligned along the magnetic field H, and embedded in a medium of electron density N drifting perpendicularly to H with velocity V, drifts relatively to the matrix medium with the velocity:

$$v = -V\epsilon/(2+\epsilon) \tag{1}$$

where $\epsilon = \Delta N/N$ and may have any numerical value. (It is easy to show also that a sphere of corresponding density drifts with the velocity $v = -V\epsilon/(3+\epsilon)$.) In both cases the motion is simple; there is no distortion of the cylinder or sphere, which moves like a solid through the medium without interchange of ionization at its surface.

These results have been applied recently to explain the occurrence of 'spread F', and the scintillation of radio stars. It has been shown that the ionization on the under-surface of the F-region is kinematically unstable when the region is drifting upwards. At such times a small irregularity (A in Fig. 1) drifts downwards relatively to the region and becomes a large irregularity (as at B) capable of producing the pronounced scattering responsible for scintillations and 'spread F'. It has been shown that the magnitude of the inhomogeneities thus produced seems quantitatively adequate, while the times at which these phenomena should occur agree well with the known morphology of the occurrence.

At first sight it might appear that these simple considerations could also be applied directly to explain the formation of sporadic E-region ionization. Here, however, a difficulty appears. For the phenomenon depicted in Fig. 1 to occur it is essential that the life (relaxation-time) of the ionization in the irregularity be substantially longer than the time required to drift from A to B. This condition is adequately satisfied in the F-region, where the relaxation-time of the (night-time) ionization is about 2 hr.; it is certainly not satisfied in the (day-time) E-region, where the relaxation-time is only 3 or 4 min.

The difficulty disappears when the Hall conductivity of the E-region is taken into consideration. In such a medium it has been shown that movement of a cylinder like a solid body is impossible. However, movement of a cylindrical perturbation of N is possible in such a way that there is constant interchange of ionization between the cylinder and the medium at the surface of the cylinder. In other words, a cylindrical perturbation of ionization travels through the medium as a kinematic wave. For such a wave to be propagated from A to B and so produce a major inhomogeneity it is not necessary for the time of travel to be less than the relaxation-time of the medium; it suffices if the wave travels a distance comparable

with the radius of the cylinder in a time less than the relaxation-time. This condition is frequently satisfied in the E-region of the ionosphere for cylinders of less than about 1 km. diameter.

It can readily be shown that the velocity of the wave relative to that of the moving medium, and in the direction of the latter motion, is:

$$v = -\frac{V\epsilon(2+\epsilon)}{4(1+\epsilon)\cos^2(\alpha-\beta)+\epsilon^2} \tag{2}$$

where $\tan\alpha, \beta$ are ω_e/ν_e, ω_i/ν_i respectively, $\omega_{e,i}$ being the gyro frequencies and $\nu_{e,i}$ the collisional frequencies of the electrons and ions.

There is also a component of the wave velocity perpendicular to V, but in the ionosphere this cannot of itself lead to the generation of substantial inhomogeneities as it is mainly horizontal.

It will be noted that at heights of about 100 km., where $\cos(\alpha-\beta)$ is about 1/20, $|v|$ may be up to five times $|V|$: the wave of inhomogeneity travels up to five times faster than the general drift of the medium. It seems almost certain that these waves are responsible for the production of equatorial sporadic E-region ionization, which appears at the times of solar, lunar and magnetic disturbances when the drift motion in the E-region is upwards and the wave motion consequently downwards for ϵ positive, thus leading to pronounced irregularities on the under-surface of the region. (For ϵ negative the wave motion is, of course, upwards, small deficiencies in N in the lower part of the region being transferred upwards to appear as substantial 'holes' near the ionization peak.) The recent discovery that irregularities in sporadic E-region ionization at the magnetic equator are aligned horizontally along the geomagnetic field is also in accord with this finding. It also seems likely that these waves are responsible for much of the sporadic E-region ionization found in moderate latitudes. Their importance in auroral latitudes can be assessed only after further studies.

It is remarkable that the same basic fact, kinematic instability in the ionization gradient of a medium drifting across a magnetic field, should appear to be responsible for three geophysical phenomena, namely, scintillation of radio stars, spread F, and at least some forms of sporadic E-region ionization. However, no new concept is involved; the relevant conclusions follow from the application of well-established electrodynamical principles to known ionospheric facts. The only approximation assumed is that the radius of the perturbation should be much less than the scale-height of the ionized region, a condition which seems safely satisfied in both regions E and F. Indeed, if these phenomena did not occur in the relevant parts of the ionosphere, it would seem to be necessary to explain why they were absent at the times and places where the ionization is known to have appropriate upward drift.

MARTYN, D. F. A survey of some F2-region problems. IN: Beynon, W. J. G., ed. Monograph on Ionospheric Radio, XIIIth General Assembly of URSI, 35-38 (Elsevier Publishing Co., New York, 1962).

The anomalies appearing in the F2 layer, namely the winter and summer anomaly, the magnetic equatorial behavior and the slow rate of recombination at night are discussed. In the case of the winter-summer anomaly, the noon ionization density of the F2 maximum is higher in winter than in summer. At the magnetic equator the maximum ionization displays a "bite out" in the middle of the day at Huancayo. The sunspot cycle variation is about three times greater in the F2 than in the F1 layer. In constructing a realistic theory of the F2 layer it was found that calculations at 300 km height, taking an electron density of $10^6 cm^{-3}$, give collision frequencies of 900, 1.1 and 40 sec^{-1}, respectively, for the mechanisms of collision between electrons and ions, ions and neutral molecules and electrons and neutral molecules. A consideration of vertical diffusion on the basis of new data that the gas density at the heights of the F2 region is much less than supposed hitherto. The diffusion equation can be written as:

$$\frac{\partial n}{\partial t} = q(z,t) - \beta(z) N + \frac{{}^{2}g \sin^2 I}{H_0 v_i(z)} \left\{ \frac{\partial^2 N}{\partial z^2} + \frac{3\partial N}{2\partial z} + \frac{N}{2} \right\} - v\frac{\partial N}{\partial z} - \mathrm{div}\,(uN)$$

The velocity with which the height of the layer maximum moves is given by:

$$W = -a \exp[-z] + b \exp[-z] - c \exp[-z] - v.$$

With positive values of W the layer rises but the diffusion brings it down again.
MGA

MASON, R. G. Spatial dependence of time-variations of the geomagnetic field on Oahu, Hawaii. Trans. Am. Geophys. Union 44, 40 (March 1963).

Two portable, three-component variographs have been used, in conjunction with the Honolulu Magnetic Observatory, to compare time changes of the geomagnetic field at seven points on the island of Oahu.

Marked differences that were found between Z records at stations only 20 km apart amounted in some cases to phase differences of more than 30° in the 24-hr harmonic of the daily variation and to a complete reversal in sign of short-period disturbances (1 hr or less). Small differences were also noted between the D and H records. A detailed analysis has been made using standard power spectrum techniques. The differences are explained as arising from the diversion around the island of electric currents, induced in the ocean by time changes of the primary field. It is concluded that the optimum position for making geomagnetic measurements on an island is near its center, and that data from an observatory located elsewhere must be treated with caution.
A

MASON, R. G. The equatorial electrojet in the central Pacific. SIO reference 63-13, Marine Physical Laboratory of the Scripps Institution of Oceanography, San Diego, Calif. (1 May 1963). AD-409 139.

This report discusses data from three temporary magnetic stations operated on Jarvis, Fanning and Palmyra islands during the IGY. These islands span about 6 degrees of latitude near the 160th W. Meridian. Jarvis, the most southerly, lies at latitude 0 degrees 23'S, about 1 degree N of the magnetic equator. A mean Sq range in H at Jarvis of 151 gamma, (compared with 78 gamma at Fanning) confirms the presence of the equatorial electrojet in the Central Pacific. Taking as a model of the mid-day current system a band of eastward-flowing current 630 km wide at 100 km height, its mean center was found to lie about 1/2 degree S of Jarvis and to move seasonally through about 1/2 degree of latitude in a direction away from the summer hemisphere. A study of sudden commencements, solar flare effects, etc., shows that they too are controlled by electrojet currents. There is evidence that these flow in a narrower band than the Sq currents. Power-spectral studies in the range 120-3 minutes suggest a continuously narrowing band with decreasing period. They show also that power densities decrease approximately as the inverse square of the frequency. This is characteristic of integrated white noise and could result from applying a white-noise source to an inductive system. The spectra are almost certainly influenced by electric currents induced in the ocean by the varying external field, but there are no obvious effects attributable to geological differences between stations.
DDC

MATSUSHITA, S. Intense Es ionization near the magnetic equator. J. Geomag. Geoelec. 3, 44-46 (1951).

Worldwide Es ionization was examined from monthly median values of fEs at many stations (see Fig. 1). Meridional distributions of Es ionization on geomagnetic and magnetic latitudes are better arranged than that on geographic latitudes, as well as cases of occurrence-frequencies of Es (1) (2). As shown in Fig. 2, it seems fEs on geomagnetic latitudes in the day-time (mean values of 09h. to 15h.) distributes proportionally to $\cos X$, where X is the sun's zenith distance. (Curves in the figure are obtained assuming that hour-angles are 0° and the sun's north declinations are respectively 3° and 20° for September and May.

MATSUSHITA, S. Intense sporadic-E near the magnetic equator and at the auroral zone. Rept. Ionosphere Res. Japan 6, 118-119 (1952).

During the day-time there is a narrow intense E_s zone near the magnetic equator which may be related to the eastward intense electric current flow producing the daily magnetic variation. During the night intense E_s occurs in the auroral zone, probably due to solar corpuscles. (See also Proc. Third Meeting Mixed Commission on the Ionosphere International Council of Scientific Unions, Canberra, Aug. 24-26, 1952.) PA

MATSUSHITA, S. Intense sporadic-E near the magnetic equator. Rept. Ionosphere Res. Japan 6, 123-124 (1952).

It was reported by the writer (J. Geomag. Geoelect., 3, 44, 1951, and see this issue) that sporadic-E (E_s) in the day-time (mean of seven monthly-median-values from 09 h to 15 h) was abnormally large near the magnetic equator.

But, fE_s values are, unfortunately, not always accurate (K. Rawer, I. C. S. U., Mixed Commission on Ionos., p. 114, 1951, and H. Hojo in this issue), because they depend essentially on the data of apparatus.

And so, occurrence frequencies of fE_s for 22-02 h, 03-08 h 09-15 h and 16-21 h in each month are examined for stations of Fraserburch, Slough, Washington, Wakkanai, Akita, Kokubunji, Yamagawa, Okinawa, Taipeh, Singapore, Falkland Is., Brisbane, Canberra, Hobart, Macquarie Is. and Huancayo, for the purpose of examination of reliableness for intense E_s zone near the magnetic equator.

The occurrence frequencies for 09-15 h at Huancayo have some peculiarity, comparing other stations. They have three maximum frequencies at about 4.7, 8.0 and 10.3 Mc/s, though they vary in each season. It cannot be simply decided as errors due to the apparatus only. And the

feature of the intense E_s zone near the magnetic equator may be not largely deformed, even if unreliableness due to apparatus is considered, because already studied median values are nearly equal to median obtained from smoothing distributions of these occurrence frequencies.

On the other hand, fE_s during the magnetic storm time at Huancayo is researched. In the daytime it seems to decrease, and at night it increases except June Solstice.

A

MATSUSHITA, S. Ionospheric variations associated with geomagnetic disturbances. I. Variations at moderate latitudes and the equatorial zone, and the current system for the S_D field. J. Geomag. Geoelec. 5, 109-135 (1953).

Variations in the densities and heights of the ionospheric Es- and F2-regions during magnetic storms are studied. At moderate latitudes in summer solstice and at the equatorial zone, the disturbance variation of the Es in both local time (S_D) and storm time (Dst) is obtained by statistical examination, although the individual values of the Es data may not always be accurate. The amplitude of the S_D variation of the Es at the moderate latitudes is about 0.5 Mc/s in frequency (15% for mean ionized density), and the phase of the variation seems to be opposite to that of the F2. At the equatorial zone, the S_D variations of the Es- and the F2-regions and the Dst variation for f_0F2 are rather peculiar for the phase, compared with those at the moderate latitudes. The geomagnetic S_D variation at this zone is also a little different from that in the moderate latitudes. In addition the current system for the S_D field is calculated by the dynamo theory, taking into consideration the anisotropic electrical-conductivity. A production mechanism of the Es is supposed, and the possibility that the ionospheric S_D variations are due to the effect of a drift by the earth's magnetic field and the electric field of the S_D current is discussed.

PA

MATSUSHITA, S. Lunar tidal variations in the sporadic E-region. Rept. Ionosphere Res. Japan 7, 45-52 (1953).

Finds maximum amplitude of lunar semidiurnal variation of fE_s for 1 yr resembles that of F2 though larger in summer, especially for middle latitudes. Magnitude of height variation resembles F1. Says maximum height variation occurs about 6 hr after lunar culmination and maximum for fE_s occurs 2 - 3 hr later still.

M

MATSUSHITA, S. Some studies on the Es region. Disturbance variations of the Es region and the current-system for the S_D field. Proc. Mixed Commission on the Ionosphere, Brussels, 16-18 August 1952, 194-211, (1954).

The Es variation associated with geomagnetic disturbances, S_D(Es), is studied statistically. Its amplitude is about 0.5 Mc/s and the variation shows peculiarities near the magnetic equator. The S_D current system required by the dynamo theory is calculated theoretically, taking into consideration the anisotropic conductivity, and it is concluded that the S_D (Es) variation may be due to vertical drift effects associated with the S_D field.
PA

MATSUSHITA, S. Ionospheric F2 variations associated with geomagnetic disturbances at the equatorial zone. IN: Physics of the ionosphere, 265-269 (The Physical Society, London, 1955).

The disturbance daily variations and the storm-time variations in the minimum virtual height and in the critical frequencies of the F2-layer at Huancayo have been studied. A sharp maximum of the disturbance daily variation occurs at about 05 hr. The S_D variation for the geomagnetic horizontal component at Huancayo was also examined. That variation has some peculiarity compared with at moderate latitudes. This result is explained by the S_D current system calculated by the dynamo theory, taking into consideration the anisotropic electrical conductivity. The sharp maximum in the disturbance daily variation of h'F2 at Huancayo is explained by theoretical consideration of the drift produced by the electric field of the calculated S_D and the earth's magnetic field.
PA

MATSUSHITA, S. Sequential Es and lunar effects on the equatorial Es. J. Geomag. Geoelec. 7, 91-95 (1955).

No abstract available.
PA

MATSUSHITA, S. Lunar effects on the equatorial Es. J. Atmos. Terrest. Phys. 10, 163-165 (1957).

States equatorial Es intense during daytime but occasionally disappears about noon or in early afternoon; usually continues till evening. Plots E_s disappearance time at Huancayo vs lunar age. Finds equatorial E_s often disappears earlier than usual around full and new moons. Shows that solar time of disappearance vs lunar hour yields much clearer relation. Concludes

Es often disappears around noon or early afternoon if these times lie between 0000 and 0300 or between 1200 and 1500 lunar time, i.e., Es often disappears during first half of periods of westward lunar electric-current flow. Thinks Es may be caused by vertical upward drift due to eastward electric-current jet. Explains disappearance of Es by assuming vertical upward-drift force due to eastward electric current of solar magnetic variation is weakened by downward-drift forces due to westward electric current of lunar magnetic variation.
M

MATSUSHITA, S. A study of the morphology of ionospheric storms.
J. Geophys. Res. 64, 305-321 (1959).

A study was made of the variations of the maximum electron number density in the ionospheric F2 layer during magnetic storms. Fifty-one strong storms and 58 weak storms were studied. The data were collected during the ten-year period 1946-1955, at 38 ionospheric stations between 60.4° N and 60.4° geomagnetic latitudes. The ionospheric stations were put into eight zones according to their geomagnetic latitudes. Storm-time variations in the maximum electron number density (Dst) and disturbance daily variations during each six-hour period (DS) were obtained for each of the eight zones.

The Dst variation in higher middle-latitudes was characterized by an initial short increase followed by a much larger decrease, the amplitude of the decrease being accentuated in summer. In the equatorial region, however, the phase of the variation was the opposite of that in higher latitudes. There was generally an increase after an initial short decrease, with no seasonal effect. The Dst variation at intermediate latitudes resembled that at higher latitudes in summer and that at the equatorial region in winter, with the average over all seasons being relatively flat.

The diurnal component of the DS variation for each six-hour period indicated, on the harmonic dial, a change in the clockwise sense except in the equatorial region. The maximum amplitude of the diurnal component of the mean of the DS variations showed a gradual decrease from higher toward lower latitudes with a subsequent increase in the equatorial region. A remarkable change of the phase of the diurnal component also occurred from higher toward lower latitudes.
A

6

MATSUSHITA, S. On artificial geomagnetic and ionospheric storms associated with high-altitude explosions. J. Geophys. Res. 64, 1149-1161 (1959).

Geophysical effects of nuclear explosions at Johnston Island on August 1 and 12, 1958, were studied by means of IGY geomagnetic and ionospheric data collected at various stations in the Pacific area and the American continent. The explosion heights are estimated at 70 to 80 km and about 40 km, respectively. Immediately after each explosion, three phenomena occurred. (1) Strong counterclockwise circular electric currents were formed in the vicinity of Johnston Island at 80- to 100-km height. They caused the immediate occurrence of artificial magnetic storms in the central Pacific. (2) High-energy particles moving along the magnetic lines of force caused auroras seen from Apia, and also caused the main parts of the magnetic storms observed at Apia. (3) X-rays due to the explosion caused the increase of the D-region absorption observed at Maui.

Irregularities of the electron density in the F-layer at Maui and the maximum geomagnetic change at Honolulu were caused by a shock wave from the explosion. The degree of ionization in a wide area in the central Pacific increased to about 10 times normal within 35 min after the first explosion and within about 6 hr after the second. Then a strong radio absorption continued for many hours,

A

MATSUSHITA, S. Interrelations of sporadic E and ionospheric currents. IN: Smith, E. K., and S. Matsushita, ed., Ionospheric Sporadic E, 344-375 (Macmillan Company, New York, 1962).

Several different electric current systems in the ionosphere at about 100 km altitude have been postulated from studies of quiet and disturbed variations of the geomagnetic field. Almost all of these ionospheric current systems are related to different types of sporadic E (E_s), although the mechanism involved in the relationship is not the same in each case.

It is suggested that equatorial E_s is a kind of irregularity in the equatorial electrojet due to vertical drifts. E_s occurring in temperate latitudes is postulated to be mainly a thin patchy layer which is due to vertical drift motions of charged particles caused by wind shears; however, occasionally a thick cloud is formed by descending ionization from the upper ionosphere. In both cases E_s is affected by the solar daily quiet ionosphere current. In high latitudes predominant types of E_s, such as slant, retardation and auroral types, together with the disturbed ionospheric currents, are due to charged particles penetrating into the lower ionosphere from outside the earth's atmosphere, as can be clearly seen during geomagnetic bays. This interrelation also occurs occasionally at the time of geomagnetic sudden commencements, Retardation type of E_s and so-called night-E are thick patchy layers, and auroral E_s is formed by field-aligned clouds, all of

which are caused mainly by electron impact. These interrelations of E_s and ionospheric currents are discussed in the present article and an estimation of structures and causes responsible for the different types of E_s is presented.
A

MATSUSHITA, S. Ionospheric variations during geomagnetic storms. IN: Proc. International Conference on the Ionosphere, London, July 1962, 120-127 (The Institute of Physics and the Physical Society, 1963).

Different types of ionospheric data are used to investigate the ionospheric variations at the beginning of geomagnetic storms. Also, the Central Radio Propagation Laboratory electron density profiles are used in studies of the average variations during storms.

Soon after sudden commencements, an increase in ionization in the lower ionosphere often occurs at high latitudes; a variation in the height of the E layer occasionally appears at low latitudes. When geomagnetic micropulsations are associated with sudden commencements, the ionosphere also shows a similar period of oscillation.

The storm-time and the disturbance local-time variations of each parameter of electron density profile data show a remarkable dependence on season and latitude. Interesting relations are found between height and density variations.
A

MATSUSHITA, S. Equatorial ionospheric variations during geomagnetic storms. J. Geophys. Res. 68, 2595-2601 (1963).

During geomagnetic storms, ionospheric Dst variations in the magnetic equatorial zone and low latitudes seem to be characterized by an increase of the maximum electron density of the F_2 layer. This increase is confirmed by the electron density profile data. Possible causes of the increase are discussed.
A

MATTHEW, E. M. Preliminary survey of results of observations of field-aligned irregularities from Brisbane. Scientific Rept. 4, Contract AF 64(500)9, Queensland University, Australia, (Nov. 1961). AD-286 379.

Preliminary results of an investigation into aspect-sensitive reflections from field-aligned irregularities, undertaken at Brisbane, are discussed.

Such echoes were seen to occur at nighttime in the direction of geomagnetic south, with either a U-shape or a patchy appearance. The peak of the diurnal occurrence was at local midnight. The fading rate was generally faster than that of ground back-scatter echoes. Echo durations were usually of the order of 2 hours. The range distribution had a peak of occurrence between 1500 and 1700 km virtual slant range from Brisbane. Range spread along the 180 deg geomagnetic meridian was usually between 100 and 150 km; apparent speeds of motion along this merdian were most commonly less than 200 km/hour. Northwards motion predominated before local midnight and southwards after this time. The mean azimuths of observed echoes showed a westward deviation with increasing time, due to ionospheric effects, and also a westward deviation with decreasing range. Possible correlation existed between echo occurrence, radiostar scintillations and spread F. Some magnetic control of echo occurrence and behavior was observed.
DDC

MATTHEW, E. M. Further results of observations of field-aligned irregularities from Brisbane. Scientific Rept. 12, Contract AF 64(500)9, Queensland University, Australia (March 1962). AD-294 609.

Results of an investigation into the characteristics and behaviour of echoes from F-region field-aligned irregularities as observed at 16 mc/s from Brisbane over the period August, 1960 to August, 1961, are discussed. The echoes (classified as patch or U-echoes) were observed either by direct reflection ('short-range' echoes) or as 'long-range' echoes, either by intervening reflections from the F-region and ground, or by direct reflection at times of steep horizontal ionospheric gradients. The diurnal variation of FAE occurrence was related to prevailing ionospheric conditions, long-range echoes occurring at times when foF2 is high and h'F is low, and short-range echoes when foF2 is low and h'F is high. U-echoes typically showed azimuthal spreads 20 degrees greater than those of patch echoes. U-echoes were found to occur preferentially at times of magnetic disturbance; magnetic control of sense of motion (northwards with increasing magnetic disturbance), and of range-spread (decreasing with increasing disturbance) was observed.
DDC

MATTHEW, E. M., and E. W. Dearden. Radar observations of field-aligned irregularities during the two magnetically disturbed days, May 6, 1960 and May 8, 1960. Scientific Rept. 15, Contract AF 64(500)9, Queensland University, Australia (March 1962). AD-294 699.

Further evidence is presented for an association, postulated by Dearden (1962), between the Outer Van Allen Belt, the FAI arcs observed

from Brisbane, and the 6300 A airglow arcs. The phenomena associated with a discontinuous increase in the northward speed of an FAI arc are studied and the event is interpreted as arising from some form of impact on the magnetosphere. The occurrence of an annular echo and its associated phenomena is interpreted as an observation of the Outer Belt dumping radiation into the atmosphere.
DDC

MAYAUD, P. N. A new system of magnetic coordinates for the study of the upper atmosphere: The coordinates of the equatorial ring. Ann. Geophys. 16, 278-288 (1960). (In French.)

Because of the part played in phenomena of corpuscular origin by the lines of force of the real magnetic field, it is proposed that these phenomena be classified in their studies by substituting for the dipole-coordinates a representation of the real field obtained from the extremities of the lines of force of the real field which issue from circumferences of the equatorial plane. With the aid of calculations based on harmonic spherical analysis carried out by Hultqvist, charts are drawn which permit the coordinates in this new system of any point on the earth's surface to be easily determined. Some examples justify the soundness of this substitution.
PA

MAYAUD, P. N. Equatorial electrojet and magnetic activity. Ann. Geophys. 19, 164-179 (1963). (In French.)

The magnetic activity is analysed, by K-indices, on a three-years sample in an observatory located under the electrojet and in some observatories outside it. The amplification of activity caused by the electrojet, in close relation to the amplification of S_q, is estimated to be at least 3 during strong agitation, and 5 during weak agitation. An interpretation of this phenomenon is suggested: it would be due to a perturbation created by the planetary magnetic activity; it would therefore be a secondary phenomenon.
PA

MAZUMDAR, S. C., and S. N. Mitra. Peak amplitude recorder for investigation of fading. Indian J. Phys. 28, 251-255 (1954).

On pulsed transmissions, the different order ionospheric returns are received at distinct time intervals and they are represented as separate echoes. This paper describes an experimental arrangement which can select any one of these 'echoes' and record its amplitude variation.
A

McINERNEY, R. E., J. C. Ulwick, and W. Pfister. Direct electron density measurements in a satellite up to one earth radius. Upper Atmosphere Physics Laboratory, Air Force Cambridge Research Laboratories, Cambridge, Mass. (1964).

An impedance probe, operated in two frequencies, was flown on satellite 1962 Betta Kappa together with several trapped radiation experiments. Roughly 50 orbits of tape recorded data were collected in the first eight days. Real time data were recorded for the next two months. Electron densities were measured from the peak of the F layer to 5500 km. The electron densities above 1500 km were fairly constant at a value of about 4000 electrons per cm^3. Day to day, latitude, and local time variations of densities are studied.
A

McNICOL, R. W. E., and G. de V. Gipps. Characteristics of the E_s region at Brisbane. J. Geophys. Res. 56, 17-31 (March 1951).

The E_s region as recorded on routing h'f records taken at Brisbane (latitude 27°.5 south, longitude 153°.0 east) between June 1943 and December 1949 has been studied. At all seasons the critical frequency is lowest at dawn. In summer months, the critical frequency reaches a maximum at about 10^h and then declines gradually, remaining high until after midnight. In winter, the rise is slower and the maximum critical frequency occurs around 14^h, dropping markedly by sunset. In general, a high E_s critical frequency is accompanied by blanketing of F echoes up to a comparatively high frequency; but, whereas the

occurrence of high critical frequencies shows a summer maximum and a winter sub-maximum, the occurrence of high blanketing frequencies is least frequent in winter. The observations suggest that there are two distinct types of E_s common at Brisbane—one formed at greater heights and descending to its final position, the other formed in situ. The first, the predominant type in summer, blankets strongly and has probably a uniform ionization density; but the second, the winter type, blankets little and probably has pronounced lateral irregularities. No evidence of correlation could be found with sunspot numbers, ionospheric storms, or meteor occurrence frequency, and the conclusion is reached that the Brisbane E_s is not predominantly of meteor origin. There is some slight evidence of correlation between the constant-height type of E_s and F region diffuseness.
A

McNICOL, R. W. E., H. C. Webster, and G. G. Bowman. A study of "spread-F" ionospheric echoes at night at Brisbane. Austral. J. Phys. 9, 247-271 (1956).

At frequencies well below the critical frequency, satellite echoes sometimes accompany the night-time F_2 echo, sometimes clearly separated, sometimes overlapping. In an investigation of these range multiplets, in addition to routine P'f sounding records, continuous virtual range measurements at fixed frequency (at stations of various separations), and measurements of mean intensities, phase-path changes, and directions of arrival, have been carried out.

From a study of the results, certain simple relationships emerge, as first approximations, between the various quantities measured, namely; virtual ranges (group paths), phase-path change, zenith angle, azimuth, intensity, and the time. A parameter having the dimensions of velocity, appearing in these relationships, has values of which 80 percent lie in the range 240 ±140 km/hr, with directions of which 80 percent lie in the range 290 ±60°. The mean duration of a satellite is 50 min. Satellites occur more frequently in winter than in summer and show a somewhat complex diurnal variation, which is described in detail, and which tends to recur from year to year. It is associated with the general night-time changes in equivalent height of the layer. Strongly reflecting E_s shows an inverse diurnal variation. No correlation with geomagnetic disturbance indices could be found.
A

McNICOL, R. W. E., and G. G. Bowman. Latitude variations of frequency of occurrence of "spread-F" satellite traces. Austra. J. Phys. 10, 588-590 (1957).

Night-time "spread-F" satellites, revealed as discrete extra traces of range greater than the main F-region echo on ionograms (h'f records) have been recorded by McNicol, Webster, and Bowman (1956) as part of the spread-F phenomenon at Brisbane. This report is an investigation of the relative frequency of occurrence of such satellites at different latitudes.
A

McNICOL, R. W. E., J. S. Mainstone, and J. R. Wilkie. Micropulsation studies at Brisbane, Queensland II. Pulsations of the Pc and Pt type. IN: Proc. of the International Conference on the Ionosphere, London, July 1962, 169-176 (The Institute of Physics and The Physical Society, London, 1963).

Micropulsations in the period range 4-100 sec were recorded with equipment sensitive down to 0.001γ sec^{-1} on both paper chart and magnetic tape. Analysis of the tapes was made with a Kay Electric sonograph frequency spectrum analyser, the tapes being speeded up by a factor of 44000 on replay, so that one complete day's record appeared on each sonagram. It was found that Pc pulsations were strongest during daylight hours, and had an amplitude which depended on magnetic Kp index, being approximately 0.3γ peak-to-peak when Kp = 3. The spread in the frequency spectrum of the Pc pulsations depended both on time of day and Kp index, being greatest at mid day, ranging then up to a maximum value which was proportional to Kp, being about 0.1 c/s when Kp = 3. The lower limit of the frequency spectrum was almost independent of Kp index and time of day, being usually about 0.02 c/s. When Kp = 0 the pulsations were not detectable on the chart records but could be seen weakly on the sonagrams during the daylight hours only, confined throughout this time to the frequency range 0.02 to 0.04 c/s.

Pulsations of Pt type could be distinguished from Pc on the sonograms by their characteristically short duration and more widely spread frequency spectra. It was found that Pt's occurred most often in the late afternoon and at night, being most common around 2100 hours L.M.T. The occurrence of Pt's also depended on the degree of magnetic activity, and was closely correlated with the occurrence of magnetic bays, the amplitude range of the Pt being proportional to the value of dH/dt for the associated bay.
A

McNISH, A. G. Geomagnetic coordinates for the entry earth. Terrest. Mag. Atmos. Elec. 41, 37-43 (1936).

During a recent investigation it was found necessary to construct a system of geomagnetic coordinates covering the entire Earth. As these may be found useful to those engaged in terrestrial-magnetic, cosmic-ray, and other geophysical researches for finding the geomagnetic coordinates of various places the nomographs prepared are reproduced herewith. Excerpt

McNISH, A. G. Progress of research in magnetic diurnal-variations at the department of terrestrial magnetism, Carnegie Institution of Washington. Int. Ass. Terrest. Mag. Elec. Bull. 10, 271-289 (1937).

The establishment of a magnetic observatory by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington near Huancayo, Peru, in geographic latitude 12.°0 south - geomagnetic latitude 0.°6 south - has led to the discovery of magnetic diurnal-variations markedly different from those expected for such a region. The anomalous character of the diurnal variations at this station is most conspicuous in the extremely large range in horizontal intensity - for example, the range in this element was 106 gammas for the international quiet days of the equinox of 1923 as compared with 32 gammas observed for the same time at Samoa, in geographic latitude 13.°8 south and geomagnetic latitude 16.°0 south.

Examination of the variations observed at other stations in about the same longitude as Huancayo indicates that they exhibit certain features which seem to fit into the concept derived from examination of the Huancayo variations. With a view to more clearly understanding the variations of these stations in the Western Hemisphere, a spherical harmonic analysis of them was undertaken.
Excerpt

McNISH, A. G. Terrestrial-magnetic and ionospheric effects associated with bright chromospheric eruptions. Terrest. Mag. Atmos. Elec. 42, 109-122, (1937).

Magnetic changes occurring at a large number of stations simultaneously with bright chromospheric eruptions reveal that the effect is an augmentation of the normal diurnal variation supposedly due to increased atmospheric ionization by ultraviolet light from the eruption. Radio fade-outs occurring at the same time indicate that this increase of ionization takes place at the base of or below the E-layer while the upper layers are unaffected. These facts are adduced in support of the Stewart-Schuster theory which attributes the diurnal variations to dynamo-currents in the ionosphere, since the lower ionosphere is the region in which these currents are likely to flow.

The upper regions of the ionosphere are most favorable for the operation of the drift-current and diamagnetic theories. Absence of typical features of magnetic disturbance immediately after and for several days after the more intense eruptions is contrary to the effects predicted by the ultra-violet theory of magnetic storms.

Examination of the processes of ionization indicates that the solar eruptions are adequate causes of the effects observed. These eruptions must produce very large increases in ionizing radiation. It is suggested that normal radiation from the Sun in the extreme ultra-violet is much greater than that calculated on the assumption that the Sun is a black-body radiator at a temperature between 6000° and 7000° K.

Statistical examination of the phenomena suggests that differences in intensity may be adequate explanation for the production of magnetic effects and radio fade-outs by some eruptions, only fade-outs by others, and absence of noticeable terrestrial effects in numerous cases. Fade-outs reported when no eruptions occurred seem attributable to causes of a different nature.
A

McNISH, A. G., and T. N. Gautier. Theory of lunar effects and midday decrease in F2 ion-density at Huancayo, Peru. J. Geophys. Res. 54, 181-185 (1949).

It is shown that the diurnal variation of the earth's magnetic field gives rise to forced diffusion of ions in the F2 region. Calculations indicate that at Huancayo, Peru, this diffusion may account for the midday decrease in F2 critical frequency observed there. To test this theory, the F2 data from Huancayo were examined to determine if, when the solar and lunar magnetic diurnal variations are in phase, the midday values of F2 critical frequency are lower than when the variations are out of phase, as called for by the theory. The predicted effect was verified by the observations.
PA

McNISH, A. G., and T. N. Gautier. Lunar ionospheric variations at low-latitude stations. J. Geophys. Res. 54, 303-304 (1949).

Give amplitudes and phase angles by season for variations in f_0F2 at 12^h and 16^h with age of moon. At stations near geomagnetic equator, there is variation; at station 20 deg from geomagnetic equator, amplitude only 2/3 as great. At equator, fo has maxima 2 days after new and full moon, and minima 2 days after quarters; at 20 deg from equator, phase is shifted almost exactly 180 deg.
M

McNISH, A. G. Symposium on Dynamic Characteristics of the Ionosphere, IN: Proc. Conference on Ionospheric Physics, State College, Pa. 24-27 July 1950. (See also Comments by D. F. Martyn and M. H. Johnson.)

We have been investigating the lunar tides in the F_2-layer, the tidal effects, I should say, at Huancayo and other observatories. Figure 6 is an idealized picture of the diurnal variation in terrestrial magnetism caused by this current system which Dr. Martyn described as observed at Huancayo. It shows the change in amplitude at different phases of the moon. You will note on this figure that about four days after the new and full moon indicated by the solid and open circles we have the maximum diurnal variation, and four days after the quarter moon, or half moon whichever you call them, we have the minimum of the diurnal variation. This led us to look for certain tidal effects in the F_2-region on the basis of a theory which I am not so sure is correct now as I was when we found that the theory was verified by the observation. Figure 7 will show the change in the critical frequency of the F_2-layer at Huancayo. You will notice here that the critical frequency has a minimum about four days after the new moon and after the full moon, and a maximum after the intermediate phases of the moon. Also it has the double period quite characteristic of the lunar tidal effect. The amplitude here is 1.7 mc and an approximate value of a little under 9 mc corresponding to about 30 percent change in ion density. This was based upon the tabulated values and does not really represent what is happening. Now figure 8 represents these effects by vectors showing the amplitude and phase of the lunar effects. These are values at noon and we have various ionosphere stations represented on this figure. You will notice that along the geomagnetic equator all the arrows are in approximately the same direction and of approximately the same magnitude. The different seasons of the year are represented by different types of arrows. But in general the effect all along the geomagnetic equator agreed in magnitude and in direction. It was quite disturbing to us to find that at about 20 degrees from the geomagnetic equator the phases were completely reversed, and that is why I called attention to that one point on Dr. Martyns's last figure.

The daily times of occurrence and duration of visible evidence of lunar stratification during the months October 1948 through February 1949 are shown in figure 9. Time of day is plotted vertically according to the scale on the left, and days of the month are plotted horizontally. The vertical lines of the graph represent intervals during which the stratification was observed. These intervals tend to lie along diagonal lines with a slope of approximately 50 minutes per day. Dates of occurrence of new and full moon are also shown on the chart. The sinusoidal curve symbolizes the waxing and waning of the moon.

The relation of the occurrence of the stratification to lunar and solar time is clearly shown in figure 10, in which the lunar and solar times of disappearance of the stratification (e. g., the stratification "disappears" at 1615 solar time in figure 11) are plotted against each other. The times of disappearance are quite sharply confined to solar time between about 1000 and 2100 hours, and cluster distinctly about two lunar times (approximately 0815 and 2045) separated by 12-1/2 hours, which is one-half the lunar day.

Let us now view figure 11. These are the successive ionographs from Huancayo taken at 15-minute intervals, from 1230 on one day to 1615, showing how the stratification developed. You notice at 1230 that the F-region has a rather distorted look with a tremendous flattening in virtual height at a frequency of around 10 mc. Fifteen minutes later that part has risen and it continues to rise right on through the picture until a decided cusp develops, and finally as we go down to the last picture you see that the layer has split into two. I thought of getting back to our old geological and biological things and thinking of a mitosis of ionosphere in this case, so that we have this layer being formed from a division of the F_2-layer caused by the moon. That takes place very regularly, practically every day, although this is one of the most clearly cut cases of it that we have observed. The importance of this to propagation is very interesting also. The maximum usable frequency for this first figure at 1230 happends to be 37 mc. for 4000 km, propagation; the maximum usable frequency for the last slide is 25 mc. But the charts which we published giving average values for the month show that from 12:00 o'clock noon until 4:00 o'clock in the afternoon, 32 mc. was the correct frequency to use. So we find out that this rather abstruse lunar tidal effect is something which comes into considerable practical interest quite apart from its theoretical interest. There are three theories I have in mind to explain it which would take too long to expound here; the one which Gautier and I published about a year ago, the theory which Dr. Martyn put out, and another theory. I do not know which if any of these is correct, but I want to point out the very complex character of this. Now another feature of interest here is that when these ions get to this great height, which corresponds to about 700 km above the earth's surface, that is the time that the ion density attained the maximum at Trinidad. As these ions apparently fall down the lines of force, (although these would not reach as far as Trinidad) a point somewhat apart from the geomagnetic equator near the location of Trinidad would have the ion density increased by these electrons falling down the lines of force, and in that way it would explain not only the anomalous behavior of Huancayo but also the reason for the phase differences in lunar tides between the points at the geomagnetic equator and points separated from them by about 20 degrees.

Excerpt

McNISH, A. G. Geomagnetic effects of high-altitude nuclear explosions. J. Geophys. Res. 64, 2253-2265 (1959).

Two high-altitude nuclear explosions detonated near Johnston Island in August 1958 produced distinct geomagnetic effects at Honolulu, Palmyra Island, Fanning Island, Jarvis Island, and Apia. No other operating magnetic observatories reported discernible effects. The effects at the first four observatories are attributed to overhead currented caused by increased ionization of the atmosphere by γ rays and their secondaries from the detonations. The effects at Apia are attributed to charged particles from the detonations and Compton electrons released from the air around the detonation.

A

MEDNIKOV, N. V., ed. Materials of Ionosphere Research. (Krasnaya Pakhra, Moscow, 1960).

The published data are contained in two issues: July-August 1957, 80 pages with graphs, and May-June 1958, 76 pages with graphs.

Sponsoring organizations: The Interdepartmental Committee for the Conduct of the International Geophysical Year Under the Presidium of the Academy of Sciences, USSR: The IGY 1957-1958-1959; and the Institute of Terrestrial Magnetism, the Ionosphere and Radio Wave Propagation. (Moscow, Knizhnaya Letopis', No. 51, 1960, Nos 74845, 74846, p. 21)

From Soviet Bloc Research in Geophysics, No. 4, 12 (1961).

de MENDOCA, F., and O. K. Garriott. Ionospheric electron content calculated by a hybrid Faraday-Doppler technique. J. Atmos. Terrest. Phys. 24, 317-324 (1962).

When the radio signals from an orbiting earth satellite propagate through the ionosphere and are then received at the ground, two effects may be readily measured. First, the polarization of the received signals varies, due to the Faraday effect and, second, the ionosphere slightly alters the received Doppler shifts. Measurements of either of these effects may be related to the electron content of the ionosphere (Atchinson

and Weekes, 1959; Garriott, 1960; Ross, 1960; Yeh and Swenson, 1961), although it is necessary to make some assumptions about horizontal gradients in the ionosphere in each case.

Recently, a method was suggested by Burgess (1961) in which Faraday and Doppler information were used together to permit the calculation of electron content and, in this case, no assumptions about horizontal gradients or adjustments for the vertical component of the satellite velocity were necessary. This paper will present an improved and more general version of the hybrid Faraday-Doppler process devised by Burgess (1961) and later modified by Golton (1962). Calculations of the electron content for a number of "Transit" satellite passages have been made using this hybrid technique. The results will be compared with values obtained using only the Doppler information which are presented in another paper by de Mendonca (1962). This last Doppler method properly accounts for horizontal ionospheric gradients and closely agrees with the results obtained with the hybrid Faraday-Doppler method used in this paper.
A

MILLMAN, G. H., A. J. Moceyunas, A. E. Sanders, and R. F. Wyrick. The effect of Faraday rotation on incoherent backscatter observations. J. Geophys. Res. 66, 1564-1568 (1961).

The technique for studying the characteristics of the ionosphere by means of incoherent scattering of radio waves by free electrons was first postulated by Gordon [1958]. Experimental verification of this phenomenon has been demonstrated by Bowles [1958, 1961] of the National Bureau of Standards and by Pineo, Kraft, and Briscoe [1960a, b] of the Lincoln Laboratory.

In this note, preliminary observations of incoherent scattering conducted at Trinidad, WIF (10.7° N, 61.6° W), with a high-powered pulsed radar operating at a frequency of approximately 400 Mc/s, are described.
Excerpt

MINNIS, C. M. The graphical representation of the longitude effect in F_2-region. J. Atmos. Terrest. Phys. 2, 261-265 (1952).

Assuming that the type of fF_2/dip angle relation suggested by Appleton is valid, a network of geographical zones can be constructed within each of which the change of fF_2 along a line of latitude does not exceed some upper limit. A typical set of zones has been constructed but the boundaries are too complex and variable to be used in practice for the accurate representation of the geographical distribution of fF_2.

It is concluded that for commercial use the best method would be to make use of a set of hourly charts each of which would show the distribution at a fixed U. T.

A

MINNIS, C. M. Ionospheric behaviour at Khartoum during the eclipse of 25th February 1952. J. Atmos. Terrest. Phys. 6, 91-112 (1955).

Automatic h'f records were made at intervals of four-and-a-quarter minutes during the eclipse and at quarter-hour intervals on ten control days. The behaviour of both E- and F_1-layers can be explained in terms of Chapman layers having constant effective recombination coefficients ($\alpha'E = 1.5 \times 10^{-8}$ cm^3 S^{-1}, $\alpha'F_1 = 8 \times 10^{-9}$ cm^3 S^{-1}), and assuming a non-uniform distribution of the sources of ionizing radiation on the sun's disc. It has been possible to derive the positions and relative intensities of these sources from the E-layer data, and they appear to be related to the location of sources of intense green coronal radiation.

The F_2-layer response to the eclipse is consistent with the assumption of two component layers: a lower one, corresponding to the normal post-sunrise F_2-layer, which is sensitive to changes in solar radiation and has a α', and an upper one which is a later development of the lower layer but which is insensitive to solar radiation and has a small α'. Changes in the absorption in D-layer confirm the asymmetrical distribution of sources of ionizing radiation. Although fEs showed a very deep minimum about an hour after totality, there is nothing to suggest that this was an eclipse effect, nor is there any evidence for a corpuscular eclipse in F_2-layer about two hours before the optical eclipse.

A

MINNIS, C. M., G. H. Bazzard, and H. C. Bevan. Ionospheric changes associated with the solar event of 23 February 1956. J. Atmos. Terrest. Phys. 9, 233-234 (1956).

The measurements discussed in this note are based on h'f records obtained at the ionospheric observatories at Singapore, Inverness, and Slough. The magnetometer at Singapore measures the skin resistance of a mumetal wire and records a value integrated over a period of about 0 sec.

Singapore (Lat. 01° 19'N, Long. 103° 49'E)

On 23 February 1956 at 0330 UT ±5 min, a very sudden increase ($\Delta H = 58\gamma$) occurred in the horizontal component of the geomagnetic field. This was followed by a slower increase which resulted in a peak deflection, 10 min after the initial rise, of 77γ. These changes in H are shown, slightly smoothed, in Fig. 1(a) and are consistent with the occurrence of a solar flare which was, in fact, seen at Tokyo and Kodaikanal. From an examination of the original magnetometer trace, it appears as if H had returned to normal at 0440 UT.

The simultaneous increase in D-layer absorption, which normally accompanies such flares, was observed by measuring the minimum frequency (f_{min}) on which radio reflections could be obtained from the E or F layers of the ionosphere. A very rough estimate of the increase in electron density in the absorbing layer has been made by computing the ratio

$$(f_1 + f_L)^2 / (f_2 + f_L)^2 = B/B_0$$

where f_L = gyrofrequency round the vertical component of the geomagnetic field,

$f_1 = f_{min}$ on 23 February 1956,

$f_2 = f_{min}$ on control days (mean).

The resulting values of B/B_0 are shown in Fig. 1(b) in which a sudden increase has been assumed to coincide with the magnetic crochet. At 04 UT no reflection was received even from the F2 layer and, in consequence, only a lower limit can be given for B/B_0.

Measurements of the intensity of atmospheric radio noise in the h.f. band reflected the increased absorption in the ionosphere. At marked fall in intensity (17 dB) was found at 04 UT on a frequency of 15 Mc/s; the fall was not so great on 10 Mc/s (6 dB) and 20 Mc/s (4 dB), and was negligible on 2.5 and 5.0 Mc/s. No intensity measurements were made at 05 but at 06 UT the level was normal.

Inverness (Lat. 57° 27'N, Long. 04° 15'W)

The small, but abrupt, increase in B/B_0 between 03 and 04 UT is probably significant, but the most pronounced increase occurred after sunrise, and this was followed by a return to normal after sunset.

Slough (Lat. 51° 31'N, Long. 00° 34'W)

Except for the slightly higher level of B/B_0 at 09 and 10 UT, no abnormal ionospheric effects were observed.

Tentative Conclusions

(i) The magnetic crochet at Singapore and the intense and prolonged ionospheric absorption are characteristic of an important solar flare.

(ii) It seems possible that the small increase in B/B_0 at Inverness between 03 and 04 UT may be associated with the very large increase in cosmic-ray intensity which was reported to have occurred at 0345 UT.

(iii) It is very unlikely that the high values of B at Inverness during daylight were due to continued emission of wave radiation from the flare for two reasons: (a) the level of B/B_0 is much higher than the simultaneous value at Singapore where the measurements indicate that the flare has subsided to a low level by about 09 UT, (b) the difference in the level of B/B_0 at Inverness and Slough suggests that the effect at Inverness was in some way due to high-speed-particle bombardment rather than to wave radiation. The ionospheric and magnetic disturbances which began on 25 February can probably be attributed to the arrival of slow-speed particles.

(iv) The slow fall in B at Slough from 09 UT onwards may possibly have been due to the residual wave radiation from the flare, since the curve fits on fairly smoothly to the Singapore curve. If so, this would account for the slightly high values of B at 09 and 10 UT.

A

MINNIS, C. M. Ionospheric changes at Singapore during the solar eclipse of 20 June 1955. J. Atmos. Terrest. Phys. 10, 229-236 (1957).

Measurements were made, at vertical incidence, of the changes in the ionosphere which accompanied the eclipse. It has been possible to derive the distribution and intensities of the solar sources of ionization radiation responsible for the E layer during the eclipse. Although it would not have been obscured at Singapore, it has been necessary to postulate the existence of a bright source in the sun's Southern hemisphere having an intensity equal to 21% of the total radiation. This figure agrees well with the intensity (23%) derived from measurements made on the control days, of a source of radiation associated with an active group of spots which was in the South-west quadrant on 20 June.

No significant change occurred in the F2-layer critical frequency during the eclipse, but the temporary appearance of an F1 1/2 layer, in addition

to the usual permanent ledge in the F2 layer, indicates that the eclipse was responsible for a rearrangement of the electron distribution in the lower part of the F2 layer.
A

MINNIS, C. M. Ionospheric changes at Singapore during the solar eclipse of 14 December 1955. J. Atmos. Terrest. Phys. 13, 346-350 (1959).

The E- and F1-layer data obtained at pairs of stations during the eclipses of 1952 and 1954 were consistent on each occasion with a single model for the distribution of sources of ionizing radiation on the sun. The results obtained at Singapore in December 1955 cannot be explained in terms of any likely distribution. It seems possible that vertical movements, and the consequent invalidity of the Chapman theory, may have been responsible for this discrepancy. No significant change occurred in the critical frequency of the F2-layer but there is evidence of a complex redistribution of ionization in the lower part of the F-layer.
A

MINNIS, C. M., and G. H. Bazzard. Some indices of solar activity based on ionospheric and radio noise measurements. J. Atmos. Terrest. Phys. 14, 213-228 (1959).

The critical frequencies of the E- and F2-layers of the ionosphere are closely controlled by the level of solar activity but, at any fixed point on the earth's surface, they also vary with season owing to the annual change in the solar zenith angle. A critical frequency can only be used to provide an index of solar activity if such seasonal variations can be eliminated or reduced to very small proportions. Methods of achieving this are described and monthly mean values of an E- and an F2-layer index are tabulated for the period 1938-1957. The correlation of these indices with each other and with the solar noise flux at λ10.7 cm is high. Some possible practical applications of such indices are discussed briefly.
A

MINNIS, C. M., and G. H. Bazzard. The geographical distribution of ionization in the F2-layer. J. Atmos. Terrest. Phys. 18, 181-183 (1960).

For any location the monthly mean F2-layer critical frequency, fF2, can be expressed as a family of linear functions of an ionospheric index of solar activity. The intercepts of these functions have been determined for sixty-five locations at noon and form a reliable tool for investigating the geographical distribution of fF2 at minimum solar activity. It has been found that the equatorial trough in fF2 cannot be conclusively proved to exist in the western hemisphere at certain times of the year.
A

MINOHARA, T., and Y. Ito. Measurements of ionosphere heights and radio observations in South Sea Islands during solar eclipse of February 14, 1934. J. Inst. Elec. Engrs. Japan. 54, 1030-1035 (1934). (In Japanese with English abstract.)

Observations made by means of pulse method at Losap Island in South Seas; results in curves.
EI

MITRA, A. P. Tides in the ionosphere. Indian J. Phys. 24, 387-404 (Sept. 1950).

The paper presents in a connected form results of recent investigations, both theoretical and experimental, on tidal effects in the ionosphere. An account of the electromagnetic theory of tides, as developed by Martyn, is given. Results of estimation of ionospheric tides by comparative study of ionospheric data at Calcutta, Delhi and Chunking are also presented.
A

MITRA, A. P. Solar tides in the ionosphere over Calcutta. J. Atmos. Terrest. Phys. 1, 286-295 (1951).

The ionospheric data for the F_2-region over Calcutta for the period January 1946 to January 1950 are analysed with a view to determine the amplitude and phase of solar tidal drifts (both semi-diurnal and seasonal), to explain the anomalous ionization changes of F_2-region and to determine the values of the recombination coefficient in summer and in winter. Martyns mathematical analysis on ionospheric tides has been extended for this purpose. It is found that: (i) The resultant drift velocity at Calcutta is 12 km/hr in both summer and winter, and 17 km/hr in the equinoxes, being maximum downwards at 1630 in summer, at 1500 in the equinoxes and at 1330 in winter; (ii) the observed anomalous variations of F_2 ionization, both in night and in day-time, are explained taking into account the effects of both recombination and tidal drifts; (iii) the calculated values of the coefficient of recombination are all of the order of 10^{-11} cm^3/sec.
A

MITRA, A. P., and C. A. Shain. The measurement of ionospheric absorption using observations of 18.3 Mc/s cosmic radio noise. J. Atmos. Terrest. Phys. 4, 204-218 (1953).

A new technique permits measurement of the total attenuation suffered by 18.3 Mc/s cosmic radio noise passing completely through the ionosphere. It is shown that the total absorption may be divided into two components, one due to absorption mainly in the D region and the other in the F_2 region. The observations of D region absorption confirm the diurnal and seasonal variations observed by other workers. F_2 absorption depends on the critical frequency but not on the height of the region and there is evidence of increased absorption at night which may be caused by irregularities in the upper F region. The observational results are compared with those obtained by other workers and suggestions are made for the use of the method, particularly in the exploration of the upper F_2 region.
A

MITRA, A. P., and R. E. Jones. A theoretical and experimental study of the recombination coefficient in the lower ionosphere. Trans. IRE AP-2, 99-102 (1954).

The problem of recombination of electrons and ions in the lower ionosphere is studied both experimentally and theoretically. The experimental study involves analysis of new experimental data such as 150-kc radio wave absorption, polarization, and phase heights; absorption of short-wave galactic radiation; and E-region critical frequency, as well as recombination values already published. Then, by use of the theories of dissociative recombination and negative ions, a theoretical model is derived which is consistent with the experimental results. The values of the coefficient during night-time and during sudden ionospheric disturbances are discussed.
A

MITRA, A. P. A method of determining the relative amounts of D- and E-region absorptions of medium and short radio waves. Indian J. Phys. 29, 518-521 (1955).

A new method is developed by which the relative amounts of D and E-region absorptions in any medium and short wave observation may be determined purely on physical basis. The method utilizes the concept of 'relaxation time' in ionospheric levels and rests on the fact that the 'relaxation time' at the D-region levels is appreciably different from that at the E-region levels.
A

MITRA, A. P. Ionospheric Disturbances at low latitudes, J. Sci. Indus. Res. A 17, 37 (Dec. 1958).

A large number of studies have been carried out on the ionospheric changes associated with magnetic disturbances. These studies, however, refer mostly to high and middle latitudes. For low latitudes, the studies have not been quite so comprehensive.

India has for some time been running a number of ionospheric stations in the geographical zone 28° 35'N to 8° 25'N latitudes and with magnetic dips ranging from 42.44° N to 0°. They, therefore, offer great scope for the examination of characteristics of the ionospheric storms at low latitudes.

In this paper are presented a few of the results of such analysis.
Excerpt

MITRA, A. P., and K. A. Sarada. Determination of the electron content of the outer ionosphere from measurements of cosmic radio noise absorption. J. Atmos. Terrest. Phys. 23, 348-357 (1961).

Simultaneous use of ionograms and observations of cosmic radio noise taken at New Delhi have yielded approximate values of the electron content of the outer ionosphere.
JPL

MITRA, A. P., and V. C. Jain. Interpretation of the observed zenith-angle dependence of ionospheric absorption. J. Geophys. Res. 68, 2367-2373 (1963).

It is shown that the zenith-angle dependence of ionospheric absorption is profoundly affected by the nature of the height variation of the recombination coefficient in the lower ionosphere. Computations for some assumed distributions of the recombination coefficient are given.
A

MITRA, A. P., B. C. Narasinga Rao, and K. K. Mahajan. A new method for estimating loss and drift terms in the ionospheric F region. J. Atmos. Terrest. Phys. 26, 525-533 (1964).

In the F-region of the ionosphere, which has long been known to behave very differently from that predicted by the simple Chapman theory, the predominant perturbing forces, apart from the familiar production and loss processes, are the electrodynamical drifts, first postulated by Martyn (1947), and the ambi-polar diffusion of ions and electrons (Ferraro, 1945).

The resulting continuity equation is:

$$\frac{dN}{dt} = q - \beta N - \frac{d}{dh}(NV) + D \sin^2 I \left[\frac{d^2N}{dh^2} + \frac{3}{2H}\frac{dN}{dh} + \frac{N}{2H^2} \right]$$

where N is the electron density, q the rate of electron production, β the coefficient of "attachment" signifying the overall loss process, V the vertical ionic drift, D the coefficient of diffusion and I the magnetic dip. A major problem in ionospheric physics is to estimate the magnitudes of β and V as functions of height. While such attempts have been made in the past, it has been the general practice, in deducing one parameter, to make some important assumptions about the others. Thus, in the determination of β, the drift and diffusion terms have either been assumed or ignored (Ratcliffe et al., 1956), and in the determination of V, the magnitude and variation of the loss coefficient has likewise been assumed with or without consideration of diffusion effects (Chandra et al., 1960; Garriot and Thomas, 1962).

It is the purpose of this note to present a new method by which the different terms are separated with the least amount of assumption, and leads to realistic estimates of β and V. The data to be used are the true height profiles of electron density for a station near the magnetic equator (e.g. Huancayo) and a station away from it (e.g. Delhi).

A

MITRA, R. K., and M. K. Dasgupta. E_s occurrences in relation to solar activity. J. Atmos. Terrest. Phys. 25, 415-427 (Aug. 1963).

Percentage occurrence data of midday E_s (percentage of times fE_s > 5 Mc/s) for thirty-three stations in different regions of the globe were examined in relation to the solar activity for the period 1953-1959. The results obtained from statistical analysis can be summarized as follows: (i) for twenty-three stations the percentage occurrences of E_s were much greater in the sunspot maximum year than those of the minimum year and in general, these were positively correlated with sunspot activity, (ii) for three stations the reverse was the case and the correlation between the two phenomena was found to be negative and (iii) for the remaining seven stations percentage occurrences of E_s did not show any marked preference to either the minimum or the maximum year of sunspot activity and in general, for these stations, the nature of the correlation was not clearly discernible. These stations were designated as A-, B-, and C-type stations respectively. It was also observed that three distinct E_s

zones;—auroral, temperate and equatorial existed having the following characteristic features: (a) Es occurrences in majority of the temperate zone stations, irrespective of any longitudinal zone and also those in most of the auroral stations in the east intermediate longitudinal zone show definite positive correlation with solar activity, (b) for auroral stations in both the west and west intermediate longitudinal zone, the correlation is (i) negative for stations in maximum auroral frequency belt and (ii) either positive or not clearly discernible for stations outside this belt and (c) for equatorial stations the correlation is negative. It was observed that in general a well defined parabolic relation existed between the two phenomena. The high sunspot activity of the present solar cycle seems to be responsible for this nonlinear relation as also for the well defined correlations observed for the majority of the stations.
A

MITRA, S. K., and H. Rakshit. On a study of the upper ionized atmosphere in Bengal by wireless echoes of short delay. Phil. Mag. 15, 20-32 (1933).

Used group retardation method at fixed frequencies. Obtained multiple reflections. Found intensity of first echo always increased as receiver removed from transmitter by 3 or 4 km. Also number of multiples increased with distance. Find multiples in wrong relative magnitudes. Say hard to explain, but think perhaps due to different reflectivity of different parts of layer.
M

MITRA, S. K. Ionospheric studies in India. Nature 137, 503-504 (1936).

A review is given of the results of ionospheric observations carried out at various stations in India since 1930. Measurements of the equivalent height of the lower E-region gave an average value of 90 km., which is about 10% less than the value found in England by the same method. Direct measurement of the ionization density by Appleton's method showed that during the summer solstice (1933) the E-ionization density at midday was more than 5×10^5 equivalent electrons, as compared with the corresponding average value in England of 1.8×10^5. At midnight the E-ionization density was less than 2×10^5 for the greater part of the year and the F-density also less than 2×10^5 in April, May and June. The maximum value of the F-density was found to be more than 1.5×10^6, which is much greater

than the value obtained in higher latitudes. Thunderstorms were found to increase abnormally the E-region ionization.
PA

MITRA, S. K., J. N. Bhar, and S. P. Ghosh. The lower ionosphere. Indian J. Phys. 12, 455-465 (193

It is now recognized that layers of ionization maxima capable of reflecting radio waves, not unlike those existing in the upper ionosphere, are also formed in the middle and the lower atmosphere. The mode of reflection of radio waves in these dense regions of the atmosphere must be different from that in the upper E and F ionospheric regions where the collisional frequency is small compared with the exploring wave frequency and the refractive index has a value less than unity. In order to investigate the mode of reflection from these lower ionized regions, curves have been drawn depicting the variations of μ (refractive index) and κ (absorption coefficient) with N (electron density) for various values of ν (collisional frequency) appropriate for the dense middle atmospheric regions. It is found that near certain values of N depending on the value of the collisional frequency, μ increases rapidly with increasing N. If for an ionized layer in the middle or the lower atmosphere N has a value correspondong to any of these, then near its lower boundary N will increase with height and may produce large variation of μ within distances small compared with the exploring wave-length (measured in vacuum). Such regions of rapidly varying μ will be able to cause reflection of radio waves. Probable reflection coefficients of such regions are calculated with the help of the dispersion and the absorption curves using the expression of reflection coefficient for metallic surfaces. Cases considered are $\nu = 10^8$, 109 and 10^{10} per second for wave frequency 4 Mc/sec. Calculations show that for the above values of ν, the corresponding values of N near which μ rapidly changes are $10^{6.5}$, $10^{7.5}$ and $10^{8.5}$ per c.c.

Possible modes of formation of the ionized regions are also considered by applying Pannekoek's method to the cases of the first ionization potentials of O_2 (12.2 e.v.) and N_2 (15.5 e.v.). It is found that the height of the ionization maximum for N_2 agrees with the height of the E_2 layer (140 km.). Similar calculation for O_2 yields an ionization maximum the height of which corresponds to the D layer (55 km.). Lack of knowledge of the ionization potentials of O_3 prevents calculation for the ionization maximum which may possibly be produced at lower heights corresponding to the C_2 layer (30 km.).
A

MITRA, S. K. Geomagnetic control of the F2 region of the ionosphere. Nature 158, 668-669 (1946).

In a recent communication in Nature, Sir Edward Appleton has brought forward unmistakable evidence of geomagnetic control of the distribution of ionization in the F2 layer. In particular, he has shown from an examination of the world data that, "for noon equinox conditions, there is a belt of low values of fF2 circling the earth and centered roughly on the magnetic equator". The geomagnetic control raises the important question of the nature of the source of the control. Since magnetic disturbances and auroras are also subject to similar control, one can envisage, in common with the probable origins of these geophysical phenomena, two possible sources:

(1) It may be imagined that part at least of the F_2 ionization is produced by bombardment of the upper atmosphere by charged particles (after the Birkeland-Störmer hypothesis of auroras and magnetic disturbances). Further, since the points of precipitation of these particles are controlled by the terrestrial magnetic field, the geomagnetic control of F_2 layer ionization is understood. This, however, raises the old difficulty of the speeds of such particles; in order to reach low latitudes they must possess velocities approaching that of light. Such energetic particles are too penetrating to ionize atmospheric gases in the F_2 region.

(2) The above difficulty is avoided if one makes the plausible assumption that the charged particles are of terrestrial origin (after the ultra-violet light theory of auroras and magnetic storms). In the region high above the F_2 layer where the fringe of the atmosphere might be supposed to begin, the collisional frequency is very small and the electrons and ions produced by solar ultra-violet rays have very long free paths. They are thus free to spiral round the magnetic lines of force and, at the same time, are roughly guided along them, because, when formed by photon absorption, they will in general have velocity components along the lines of force. Now, at the magnetic equator the lines of force rise highest and slope north and south. The ions and electrons formed in the high atmosphere in the belt along the magnetic equator are therefore guided north and south and, when they come down to the lower levels, contribute to the ionization density of Region F_2. The densities on either side of the magnetic equator are thus increased by this 'distilling' process which operates throughout the daylight hours.

It should be mentioned at this point that the 'ultraviolet light theory' fails to explain the auroral phenomena, because, as was pointed out by Chapman, the lines of force which enter the terrestrial atmosphere near the auroral belt rise to 30,000-40,000 km. at the magnetic equator. At such heights, there being no atmosphere, the necessary charged particles cannot be formed. But, as is shown below, the theory can be adapted to explain the observed geomagnetic control of the F_2 region.

From Fig. 2 of Appleton's note, it is seen that the peaks on either sides of the magnetic equator lie in the region of magnetic dip value of about 28°. The geomagnetic lines of force which enter the earth's atmosphere in this region (dip value 19°-34°) at 400 km. level rise to heights of 600-1,200 km. over the magnetic equator. It therefore follows that if, (1) there are atmospheric particles in sufficient numbers at such heights, and (2) these particles are ionized by solar ultra-violet rays, then the ions and electrons so formed will be guided to the regions of the observed peaks of Appleton's curve. Now, direct evidence on these two points is furnished by the sunlit auroras. The fact that these auroras are observed at heights of 600-1,100 km. is evidence that there are sufficient atmospheric particles at such heights. The proof of ionization by solar radiation is furnished by their spectrum, in which the first negative bands, due to N_2^+, are greatly enhanced.

In the illustrative example, the 400-km. level has been taken as the level of entry of charged particles into the atmosphere. This is because at about this level the collisional frequency begins to be sufficiently high to prevent the particles from freely following the magnetic lines of force. Assuming the atmospheric density in Region F_2 (250-km.) level to be 10^{10}/c.c., the collisional frequency of electrons 10^3/sec. and a rising temperature of 4°K./km. above (all as indicated by radio observations), the densities at the 400-km. and the 600-km. levels are found to be of the orders of 3×10^8 and 2×10^7/c.c. and the collisional frequencies 30 and 2 per sec. respectively. For a temperature of 2,000°K. the mean velocities are 3×10^7 cm./sec. for an electron and 1.3×10^5 cm./sec. for an ion. The radius of gyration at the 600-km. level is 7 cm. for an electron and 1.6×10^3 cm. for an ion.

It is to be noted that in the high atmosphere where collisions are few and far between, the lengths of the free paths, as first pointed out by Jones, are strongly dependent on their directions. In an upward direction this length may be many times that in a downward direction.

In conclusion, attention may be directed to the fact that, according to observations of Rayleight and Spencer Jones, the seasonal variations of the intensity of night sky radiation are related to geomagnetic latitude. Since, as I have shown, the nocturnal Region F is to be identified with the luminescent layer of the night sky, the geomagnetic control of the intensity of night sky radiation can also be understood.

Excerpt

MITRA, S. N. Statistical analysis of fading of a single downcoming wave from the ionosphere. Proc. Inst. Elec. Engrs. 96, Pt. III 505-507 (1949).

The fading of a single magneto-ionic component of a radio wave of frequency 2-6 Mc/s reflected from the ionosphere at vertical incidence has been recorded at two receiving points separated by about 100 m. On several occasions it has been deduced from the records that the fading is not due to the regular drift of a constant ground-distribution of c. m. f. past the observing point, but that it corresponds to a ground distribution which is varying irregularly at all points. Records obtained under these circumstances have been analysed on the assumption that the fading is caused by the random movement of irregularities in the ionosphere according to the theory suggested by Ratcliffe.

The results agree, to a first order, with the assumption that in the ionspheric reflecting region there are irregularities moving with velocities in the line of sight which are distributed in a Gaussian manner with r. m. s. value of approximately 2 to 3 m/sec. There is, however, a significant discrepancy between the records and the results of the simple theory, and possible ionospheric causes for this discrepancy are discussed.

There is some experimental evidence to suggest that the irregularities responsible for the fading are situated below the point where waves of frequency 4 Mc/s are reflected from region E.

A

MITRA, S. N., and J. M. Roy. A modified Hammarlund Super-Pro Communication receiver for pulse measurements of the ionosphere. Electrotechnics, No. 23, 56-64 (1951).

The paper deals with the modifications that have been introduced in a Hammarlund Super-Pro Communication receiver to suit pulse measurements of the ionosphere. The criteria for a good ionospheric receiver have been first discussed. The usual limitations in a commercial receiver are their small bandwidth and low overall gain. For detecting pulses of small durations of the order of 70 μsec, one requires a minimum bandwidth of 30 kc/s in the receiver, otherwise the shape of the detected pulse gets distorted. Moreover, the existence of short time-constants anywhere in the circuit contributes to the distortion of the shape of the detected pulse. These factors have been fully taken care of in the modified receiver. It is, however, known that the receiver noise increases with the increase of the bandwidth. A compromise has therefore been achieved between the minimum noise that may be allowed and the maximum bandwidth necessary for a pulse to be detected undistorted in shape. The reduction in the noise has been achieved by increasing the gain in the high frequency stages and reducing the gain in the mixer stage. A bandwidth of 30 kc/s has been

achieved by overcoupling the i.f. transformers and then damping them by suitable resistors. A video amplifier has been provided in place of the audio frequency stages since the a.f. transformers rather restrict the bandwidth. The output of the receiver has been taken from a cathode follower stage which presents low output impedance for matching facilities. Individual stages have been fully described and a photograph of the pulses received by this receiver has been attached.

MITRA, S. N. Partial solar eclipse of 25 February 1952 and its effect on the ionosphere. J. Sci. Indus. Res. (New Delhi) 12A, 319-328 (1953).

Says all India Radio observed eclipse at Delhi, Bombay, Madras, Tiruchirapalli, and Nagpur. Used vertical-incidence ionospheric measurements at first 4 stations, field-strength observations at Delhi and Nagpur, noise studies at Delhi, fading observations at Delhi on backscatter signals, observations of pulse signals from Slough, and in addition photographed solar disc. Results in curves. Magnetic disturbance occurred near eclipse day and eclipse was partial. Attributes dip in foF2 at 1330 hr to corpuscular effects. Found no effect on E layer; attributes to irregular distribution of ionizing radiation over solar disc.
M

MITRA, S. N. Self-gyrointeraction. IN: The Physics of the Ionosphere, 71-73 (The Physical Society, London, 1955).

The phenomenon of self-gyrointeraction implies that when a sender is working near gyrofrequency, the received percentage modulation at a distant point on this transmission is markedly less than the percentage modulation impressed on the carrier at the sending end. Attempts have been made by workers in other countries to detect such lowering of percentage modulation on gyrofrequency emissions but, except in Italy, these experiments have met with little success.

An experiment has been conducted in All India Radio in February 1954 utilizing its network of medium wave broadcast transmitters to find out the effect of self-gyrointeraction. Fifteen senders covering the frequency range of 590 to 1490 kc/s were made to radiate 1000 c/s tone, the percentage modulation being kept fixed at 80. The percentage modulation of the received signal of all the senders was measured at Delhi. The curve of received percentage modulation against wave frequency shows a significant dip at 1020 kc/s where the modulation was as low as 48%. The gyrofrequency at the E layer is, therefore, 1.02 Mc/s which yields the value of H at the E layer as 0.36 gauss, the value of the magnetic field at the ground level being 0.474 gauss.

MITRA, S. N., and R. B. L. Srivastava. Analysis of sky-wave field intensity. Part I. Indian J. Phys. 29, 167-178 (1955).

The paper presents a statistical analysis of field intensity of the internal short wave stations of All India Radio over the period of a complete solar cycle (1942-52). The yearly, seasonal and monthly variations of the field intensity and their correlation with sunspot numbers have been shown in a series of graphs. An interesting feature of the analysis is that the night-time field intensity has been found to be correlated with solar activity. This is rather inexplicable since no ionospheric absorption is usually assumed for the night-time propagation.
A

MITRA, S. N. Magneto-ionic triple splitting over Delhi. J. Inst. Telecom. Engrs. 1, 124-129 (1955).

Presents some observations of the rare occurrence of triple magneto-ionic splitting over Delhi. The various possible causes for the occurrence of this phenomenon at the low geomagnetic latitude of Delhi have been discussed. It has been indicated that the triple splitting is likely to be caused by the longitudinal propagation of the ordinary ray associated with an increase in the collisional frequency of the ionospheric layers.
EEA

MITRA, S. N., and R. B. L. Srivastava. Fading and random motion of ionospheric irregularities. Indian J. Phys. 31, 20-42 (1957).

Describe statistical analysis of fading of 1-Mc/s transmission. Find rms line-of-sight velocity of random motions of ionospheric irregularities 4 to 25 m/s. Discuss amplitude distribution for random motion, and for random signals with steady component. Show how to calculate proportion of steady signal from Gaussian amplitude distribution.
M

MITRA, S. N., and S. C. Mazumdar. Some measurements of ionospheric absorption at Delhi. J. Atmos. Terrest. Phys. 10, 32-43 (1957).

The results of some measurements of ionospheric absorption taken at Delhi during June 1954 to December 1955 are described. The measurements were carried out on 5 and 2.5 Mc/s. A brief description of the experimental setup is included in the paper.

The analysis of data shows that the diurnal variation of absorption gives $|\log \rho| \propto (\cos \chi)^{0.62}$. The value of αN has been indicated from the observed value of the "relaxation time." The absorption at night has been observed to be considerable at our latitude. It has been postulated from

the low value of the exponent in the diurnal variation factor, the magnitude of the relaxation time, and from direct measurements of absorption on Es and F echoes, that the main absorption is probably taking place in the D region.
A

MITRA, S. N. Geomagnetic field and ionospheric drift. J. Inst. Telecom. Engrs. 6, 90-96 (1960).

Investigation of ionospheric drift by the well-known spaced receiver technique utilizing fading on pulsed transmission is in progress at the Research Department of All India Radio since January 1958 and forms a part of its programme of International Geophysical Year. There is some uncertainty as to the origin of this drift system at ionospheric heights. If the drifts were due to the effect of solar and lunar gravitational tides upon a uniformly rotating sphere, one would expect the drift vector to exhibit a predominant semi-diurnal periodicity. Experimental observation indicates that this is not always the case. In fact there is hardly any regular behaviour in diurnal variation of the phase of the drift system. One would, therefore, like to enquire whether earths magnetic field exercises any influence on the drift system and is responsible for irregular variation of its phase. It is likely that such an influence should exist as the ionosphere consists of charged particles. We have correlated the magnetic K index (Alibag figures) with the magnitude of the drift velocity with a view to finding out any interdependence. The analysis shows that so far as the magnitude of the drift velocity is concerned, it is fairly independent of the variation in the values of K; in fact large magnetic storms have failed to produce any significant change in the magnitude of the drift velocity. The variation of east-west and north-south components of the drift velocity during a 'quiet' day does not indicate any correlation with K; but on 'disturbed' days, the northward velocity of the north-south component increases in synchronism with increase in K.

MITRA, S. N., K. K. Vij, and P. Dasgupta. Horizontal drift in the ionosphere over Delhi. J. Atmos. Terrest. Phys. 19, 172-183 (1960).

Some results obtained at Delhi on the measurement of ionospheric drift by spaced receiver technique are described. Most probable velocities of reflections from the F- and E-layers for different seasons are indicated by histograms. The diurnal variations of the magnitude and direction of the drift velocity have been plotted graphically. Harmonic analyses of the east-west and north-south components of the drift velocity have been worked out. No predominant periodicity is any of the components was observed. It is interesting to note that the most probable direction of the drift velocity

is towards the south, and the northward component is almost completely inhibited. During magnetic storms, however, the northward component increases and its variation appears to be well correlated with the variation of the "K" index.
A

MIYA, K., T. Sasaki, and M. I. Shikawa. Observation of F-layer and sporadic-E scatter at V.H.F. in the Far East. J. Res. NBS 65D, 92-99 (1961).

This paper describes properties of sporadic-E scatter and F-layer scatter observed over the Okinawa-to-Tokyo path (1480 km) and the Philippines-to-Tokyo path (2850 km), operating at frequencies of about 50 Mc/s. Sporadic-E scatter is often observed on the Okinawa signal in the evening hours and has the closest correlation (0.94 in correlation ratio) with the occurrence of sporadic-E characterized by the descriptive symbol M of all ionospheric factors. Bearing of the E_s scatter shows a regular diurnal variation similar to that of the normal E-layer scatter, F-layer scatter generally appears on the Philippine signal in autumn when the F-layer at the path midpoint displays an anomaly denoted by the symbol R or S having a top frequency of higher than 14 Mc/s. A pulse test exhibited a pattern of multipath signals extending over more than 1 msec. Bearing of the F-layer scatter, an evening phenomenon, gradually deviates westwards from the great-circle path with the lapse of time.
A

MORGAN, M. G., and W. C. Johnson. The observed polarization of high-frequency sky-wave signals at vertical incidence. IN: Physics of the Ionosphere, 74-77 (The Physical Society, London, 1955).

In vertical incidence pulse observations made at Hanover, New Hampshire (geographic 43.7° N, 72.2° W, geomagnetic 55.1° N, 1.6° W) since December 1952, from 2.8 Mc/s up to f_0F2 (and from 1.6 Mc/s since September 1953), during the post sunrise morning hours, certain notable departures from the straightforward polarization predictions of classical magneto-ionic theory have been found consistently.
Excerpt

MULDREW, D. B. Radio propagation along magnetic field-aligned sheets of ionization observed by the Alouette topside sounder. J. Geophys. Res. 68, 5355-5370 (1963).

Some of the traces obtained from the topside sounder ionograms recorded at low latitudes are identified as being caused by propagation along magnetic field-aligned sheets of ionization. The electron-density distribution along the magnetic field line passing through the satellite obtained from one such trace is compared with the vertical electron-density distribution obtained from the regular topside F-layer traces. Close agreement of these two is obtained, indicating not only that propagation occurs along field-aligned sheets of ionization but also that radio waves propagated along the field lines are reflected very near the vertical-incidence reflection level. A study of traces resulting from propagation along field-aligned sheets of ionization reveals that the electron-density gradient perpendicular to the magnetic field of one particular sheet was approximately 4 times greater than that in the regular ionosphere. The half-thickness of this sheet was approximately 0.6 km, and the maximum electron density in the sheet was estimated to have been 1 percent above the background ionization. Radio energy that propagates at oblique incidence can become trapped by a field-aligned sheet of ionization. Thus a combination of obliquely incident propagation followed by propagation along field-aligned sheets of ionization can occur. The energy propagates along the sheet until it is reflected and then returns to the satellite along almost the same path. Improvements to an existing explanation of spread F at equatorial latitudes are suggested on the basis of this type of propagation. Radio propagation along a model field-aligned sheet of ionization is investigated by ray-tracing techniques. A ray travels back and forth across a field line, the distance decreasing between consecutive crossings until the ray becomes reflected. In a particular case investigated the ray was reflected 1.5 km above the vertically incident reflection level.

A

MUNRO, G. H. Travelling disturbances in the ionosphere. Proc. Roy. Soc. A 202, 208-223 (1950).

Methods have been developed for the examination of the horizontal and vertical movements of short-period disturbances in the ionosphere.

It has been found that quasi-periodic travelling disturbances with periods of from 10 to 60 min. are of frequent occurrence in the F region by day. They appear as temporary variations in the vertical distribution of ionization which show a horizontal progression and a vertical progression downwards.

The horizontal directions of travel have a well-defined mean direction on most days. The mean direction shows a marked seasonal variation with a sidden change at each equinox.

The horizontal rate of travel is usually between 5 and 10 km./min., and the rate of vertical progression downwards is approximately half the horizontal rate.

The disturbances are considered to be variations of a compressional type in the atmosphere resulting in changes in the distribution of ionization.
A

MUNRO, G. H., and L. H. Heisler. Cusp type anomalies in variable frequency ionospheric records. Austral. J. Phys. 9, 343-358 (1956).

Anomalous cusps which frequently appear at the high frequency end of ionosonde records of the F_2 region are explained as the result of modification of the ion distribution during the passage of typical travelling disturbances. They indicate the presence, not of vertical stratification but of horizontal gradients of ionization causing oblique reflection. It is suggested that other anomalous cusps are of similar origin.

Anomalies on records of the F_1 region are also shown to be caused by travelling disturbances.

It is demonstrated that these explanations provide useful guidance in the interpretation of ionospheric records and facilitate the further study of travelling disturbances.
A

MUNRO, G. H. Travelling disturbances in the ionosphere: Changes in diurnal variation. Nature 180, 1252-1253 (1957).

In an earlier communication it was reported that the direction of horizontal movement of travelling ionospheric disturbances observed at Sydney, Australia, had a consistent diurnal variation during winter months in the years 1950-52; but no significant diurnal variation was then apparent in the summer. These conditions continued until 1955; but in the summer of 1955-56 a definite change appeared which was even more marked in 1956-57,

the main feature being a marked change of direction from the south-east to the south-west quadrant about midday. The contrast is clearly evident in Fig. 1, which shows the mean diurnal variation in January for the years 1951-54 as compared with the variation for January 1957. The consistency of the results of 1951-54 is shown by the dotted lines, which indicate maximum deviation from the mean. It will be noted that the change from south-east to south-west quadrant in 1957 is quite sudden. This sequence is also found on a number of individual days, though not on all days. There was no significant change in mean speed over this time interval.

Examination of past records starting from the summer of 1949-50 shows that there was a tendency for a similar sequence to occur on occasional days in that year but not sufficiently often to affect the mean curve for the month. This tendency, however, decreased in succeeding years to a minimum in 1953-55. It then increased noticeable in 1955-56 and markedly in 1956-57.

It seems likely that these changes are associated with the sunspot cycle, which showed minimum activity in 1954, and which had already reached a record high value in the (southern) summer of 1956-57.

The assistance of the staff of the Sydney Section in collecting and processing these observations is gratefully acknowledged.

Excerpt

MURTY, T. V. S. Design and development of a simple ionospheric equipment. J. Sci. Indus. Res. 15A, 70-74 (1956).

A compact and simple manually operated medium power ionospheric sounding transmitter and receiver was constructed in the Banaras Univ. laboratories. The design and circuits, records and sensitivity and selectivity curves are illustrated. A cathode-ray oscillograph is used for reproducing the pulses. Scattering of radio waves can be studied by means of the pulses.

N

MURTY, Y. S. N., and S. R. Khastgir. Polarization parameters of the downcoming radio wave. J. Geophys. Res. 65, 1449-1457 (1960).

The phase difference between the normal and the abnormal components of the magnetic vector of the radio wave (i.e., the components in and at right angles to the plane containing the wave normal and the direction of the earth's magnetic field) and the limits of the tilt angle of the major axis of the polarization ellipse (traced out by the electric vector) measured anticlockwise with respect to the direction of the magnetic north for the ordinary and the extraordinary modes of propagation have been obtained on the ray theory of propagation through the ionosphere. The values are given in a table for the ordinary and the extraordinary modes in both the hemispheres for regions below and above the level of ionospheric reflection.

Scott's treatment of the same problem on the ray theory and the results given by Roy and Verma on the basis of the coupled wave equations of Saha and others are reviewed. It is shown that the discrepancies in the results of the polarization parameters obtained by different workers on ray theory are only apparent and arise out of the differences in the forms and notations used in the different formulas. It is also shown that the discrepancies in the limits of the major axis of the polarization ellipse obtained from the ray theory and the wave theory are due to the interchange in the expressions for the amplitude ratio of the normal to the abnormal components for the ordinary and the extraordinary waves given by Saha and others. The experimental results of Roy and Verma are shown to confirm our theoretical conclusions about the limits of the tilt angle of the polarization ellipse.

A

MURTY, Y. S. N., and S. R. Khastgir. Polarization curves for vertical propagation of radio waves in the ionosphere. J. Sci. Indus. Res. 19B, 281-284 (August 1960).

The curves giving the polarization angle θ and the tilt angle ψ of the polarization ellipse for vertical sounding of the ionosphere with 100 m radio waves were drawn for the condition of the magnetic field in the ionosphere above Banaras (latitude 25° 18'25"N: longitude 83° 0'46"E, dip angle 36° 26'N; and H 0.486 gauss). Three separate curves were drawn, one for each of the values of the electron collisional frequency, $\nu = 0$, $\nu = \nu_c/2$ and $\nu = 2\nu_c$ (where ν_c is the critical collisional frequency) with increasing values of the electron density which make the quantity $4\pi Ne^2/mp^2$ vary from 0 to 2, where $4\pi Ne^2/mp^2 = 1$ is the condition of reflection of the waves of the angular frequency p. In drawing these curves, use was made of the analytical expressions obtained

earlier by the authors from the Appleton-Hartree formulae giving the ratio of the normal to the abnormal components of the magnetic vector of the wave (i.e., components in and at right angles to the plane containing the wave-normal and the direction of the magnetic field) and the phase-difference between them. The theoretical basis of the computation is given and the sign convention for representing the polarization parameters θ and ψ is outlined. The nature of the variations in the polarization parameters, computed for increasing values of electron density, is discussed in detail.
PA

MURTY, Y. S. N., and S. R. Khastgir. The refractive index and the absorption index of the ionosphere. J. Atmos. Terrest. Phys. 25, 103-105 (Feb 1963).

Analytical expressions are derived from the magneto-ionic theory for computing the refractive index and absorption index for a radio wave propagating through the ionosphere for various values of electron density, collisional frequency and wave frequency. These expressions supplement those previously derived by the authors for the polarization parameters.
PA

NAGATA, T., and T. Suzuki. The solar-flare type variation in geomagnetic field and the integrated electrical conductivity of the ionosphere. II. Effect of F-layer. Rept. Ionosphere Res. Japan 4, 201-205 (1950).

Transient changes in geomagnetic field caused by the dynamo-action of a conductive layer under the effect of mutual inductance of other concentric layers are examined. The result shows that the multi-layers of the ionosphere can be replaced by a single layer, the integrated conductivity of which is equal to the conductivity integrated vertically throughout the whole conductive region. This conclusion confirms that the integrated electrical conductivity of the whole ionosphere is around 5×10^{-8} e.m.u. or less.
PA

NAGATA, T. Characteristics of the solar flare effect (Sqa) on geomagnetic field at Huancayo, Peru and at Kakioka, Japan. J. Geophys. Res. 57, 1-14 (1952).

The characteristics of solar flare type (s.f.) variations of the geomagnetic field at Huancayo, Kakioka, and Watheroo are statistically examined. The main indicators of these characteristics are the time from beginning of a s.f. variation to its maximum deviation (T_1), and the ratio of its maximum deviation to the range of daily variation at the corresponding time ($\Delta H/R_H$). With respect to both quantities, the data of the three stations show nearly the same values. The magnitude of the s.f. variations at Huancayo is abnormally large, but T_1 and $\Delta H/R_H$ show normal values.

Assuming that the s.f. variation has an abrupt increase, the integrated electrical conductivity of the ionosphere is estimated with the aid of a theoretical calculation of transient dynamo-action. The result shows that the integrated conductivity of the ionosphere amounts to $6 \times 10^{-8} \sim 7 \times 10^{-8}$ emu. over those three places.
A

NAISMITH, R. A subsidiary layer in the E region of the ionosphere. J. Atmos. Terrest. Phys. 5, 73-82 (1954).

Reasons and methods of identification are given for the recognition of an independent layer at 90-100 km height. It is suggested that the ionisation in this layer results from the impact of meteors on the atmosphere and that it may therefore be called the meteoric E-layer. The distinctive properties

may be used to extend the use of the ionosphere for intermediate distance radio communication.
A

NAKAMURA, T. Latitude effect of the oxygen red line of night airglow and its relation with the ionospheric F-layer. Rept. Ionosphere Space Res. Japan 15, 245-252 (1961).

Photoelectric observations of the 6300A emission in night airglow were carried out on board the Soya during her voyage between Tokyo and the Antarctic, and it was found that the emission has very outstanding latitude dependence. The intensity is not only strong in the equatorial zone, but the daily variation also becomes bigger compared with that in the middle latitudes. The intensity inversely correlates very well with the virtual height of the F_2 layer, simultaneously observed on the Soya. It was shown that the intensity is dependent on the density distribution of oxygen molecules which generally been acknowledged as having a share in the reaction for emitting the 6300A line with electrons.
EEA

NBS. Ionospheric data. CRPL-F127, National Bureau of Standards, Boulder, Colo. (March 1955).

World wide sources of ionospheric data are listed; tables give hourly data for Wash., D. C. and 49 other places; storms, STD's, radio propagation data, solar coronas, relative sunspot data, solar flares, etc. Also presents data in graphic form for 50 stations throughout world, both observed and predicted 5 months previously for comparative purposes. Date of data varies from Feb.-Dec. 1953 for Macquarie Island to Feb. 1955 for Wash., D. C.
N

NDRC. HF sky-wave transmission over short or moderate distances using half-wave horizontal or sloping antennas. Proj. C-79, National Defense Reserve Committee, Washington, D. C. (July 1944).

Tests undertaken under NDRC Project C-79 have been directed toward obtaining quantitative data on the relative performance of various antenna types for sky-wave use in the 2-8 mc range, and methods for adapting such antennas for use with tactical radio sets. Some of this work was done in a "semi-jungle" in Southern Florida, with the cooperation of Signal Corps personnel; further studies and tests were made at the Bell Laboratories.
A

NELMS, G. L. Influence at magnetic storms upon the distribution of ionization in the topside of the ionosphere. Telecommunications Establishment, Deference Research Board, Ottawa (1946).

The topside sounder satellite, Alouette I, provides soundings at 100 km intervals along an 80 degree orbit. A series of these soundings have been reduced to electron density profiles, and from them, contours of electron density drawn for the topside ionosphere along the 75° W meridian, from 80° N to 80° S latitude.

The diurnal variation of the electron density contours and the variations of electron distribution during the geomagnetic storm of September 21, 1963, are discussed. During this particular storm, the normal night-time redistribution of ionization in the equatorial anomaly was retarded, and the daytime ionization density at geomagnetic latitudes of 45° N (30° N geographic) was reduced.
A

NELSON, J. H. Circuit reliability, frequency utilization and forecasting in the high frequency communication band. IN: Gassmann, G. J., ed. The Effect of Disturbances of Solar Origin on Communications, Symposium of the Ionospheric Research Committee, AGARD Avionics Panel, NATO, Naples, Italy, 293-301 (Macmillan Co., New York, 1963).

This paper deals with high frequency propagation giving particular emphasis on circuit reliability, seasonal characteristics, frequency utilization,

short range and long range forecasting of signal qualities and frequency requirements. All of these features are related to the maximum, minimum, and intermediate ranges of the 11 year sunspot cycle. Particular attention is given to circuits operating between New York and the Central European area. Circuits working New York-Tangier and New York-Buenos Aires are also treated.

The long range forecasting of some recent (1960) magnetic storms associated with solar flares is treated with an explanation of the technique used for such a manner of forecasting.

A

NICHOLSON, J. R., and W. R. Steiger. On lunar semidiurnal tidal variations in the F_2 layer of the ionosphere. J. Geophys. Res. 68, 3577-3580 (1963).

Observations of attenuation of cosmic radio noise, made at 18.3 Mc/s during the period November 1958 to December 1960 at Makapuu Point, Oahu, Hawaii, have been subjected to a statistical study, and the semidiurnal lunar tidal variation has been isolated. The amplitude was found to be 0.17 decibel, the maximum occurring at 11.6 lunar hours after lunar transit. It is argued that the tidal variation observed is primarily associated with the F_2 layer of the ionosphere by citing previous studies of tidal variations in the E, E_s, F_1, and F_2 layers and comparing the phases of the variations found by other workers with the phase isolated in this study. The phase found agrees with that found for tidal variations in the critical frequency of the F_2 layer but not with variations of critical frequency in the other layers. On the other hand, it is argued that the D layer plays a minor role, owing to its absence at night and predominant role of the F_2 layer in determining the attenuation of cosmic noise when the critical frequency exceeds 10 Mc/s.

A

NICOLET, M. Effects of the atmospheric scale height gradient on the variation of ionization and short wave absorption. J. Atmos. Terrest. Phys. 1, 141-146 (1951).

A discussion of the effect of a variable atmospheric scale height is given. A linear gradient of the scale height is used and it is found that

special conditions for ionized layer formation are possible. Also, the variation of the layer critical frequency with the altitude of the sun above the horizon and of the short wave absorption are found to be affected by the variation of the scale height. The scale height variation is involved in expressions for the absorption of the solar radiation and the electronic recombination coefficient.
A

NIELSON, D. L., and B. H. Hagn. Frequency transformation techniques applied to oblique-incidence ionograms. Research Memo. 13, SRI Project 3670, Contract DA-36-039SC-87197, Stanford Research Institute, Menlo Park, Calif. (Jan. 1964).

This report discusses the application of vertical-to-oblique-incidence equivalent frequency transformations, developed several decades ago, to the problem of deducing ionospheric information usually obtained from vertical-incidence ionograms (e.g., maximum electron density in the region of reflection) by scaling oblique-incidence ionograms. The transformations of Newbern Smith and Appleton-Beynon are presented, with examples of actual records illustrating the validity of the transformations. Errors in the transformations are discussed. An effective ionosphere curvature factor, k, similar to that associated with the Newbern Smith transformation is measured for two paths. Overlays applicable to oblique-incidence records are presented and discussed.
A

NISBET, J. S., and S. A. Bowhill. Electron densities in the F region of the ionosphere from rocket measurements, Pt. 1. Methods of analysis. J. Geophys. Res. 65, 3601-3607; Pt. 2. Results of analysis, 3609-3614 (1960).

A method is described for analyzing dispersion records from long-range missiles in terms of equivalent electron-density and electron-content profiles above a fixed location. This method takes account of varying horizontal gradients in electron density and the varying local zenith angle of the ray as a function of range time and height in the ionosphere. Refraction has been considered for both Faraday rotation and range-error

measurements, and correction factors are included in the program. Comparisons made between Faraday rotation and range error measurements and between Faraday rotation measurements at two locations demonstrated the validity of the reduction techniques. In Pt. 2, electron density distributions in the ionosphere derived from propagation measurements made during seven long-range missile flights are given. These results are compared with measurements derived from variable-frequency pulse soundings and with satellite and rocket measurements described by others. The vertical electron-density gradient was found to vary within quite a large range, being lowest for two firings that took place shortly after sunset and greatest for the one early-morning firing. The equilibrium electron-density variation with height was found to be consistent with the assumption of a Chapman layer, of varying scale height, based on a recent model of the neutral atmosphere derived from satellite retardation measurements.
MGA

NISHIDA, A., and N. Fukushima. Three dimensional consideration for current-system of geomagnetic variations (II) Sq-field. Rept. Ionosphere Space Res. Japan 13, 273-282 (1959).

The equivalent electric current-system for the geomagnetic Sq variation is examined on the basis of a three-dimensional model, where the thickness of the conducting region is taken into account. The conducting region is assumed to be a spherical layer of the 70 km thick with homogeneous and isotropic electrical conductivity, and the wind velocity independent of height. The result shows that the poloidal electrical current and the associated toroidal magnetic field appearing only in a three-dimensional treatment are less than one-tenth in magnitude of the total current and field. It is concluded therefore that two-dimensional calculation hitherto made is approximately valid, so far as the vertical thickness of the conducting layer is small compared with the horizontal extension of the current-bearing layer of homogeneous conductivity.
MGA

NORTON, R. B., and T. E. Van Zandt. The equatorial F region. Paper presented to Commission III URSI, Fall Meeting, Austin, Texas, 25 Oct. 1961.

Photoionization and recombination in the F region can be approximately described by three processes: production of ion-electron pairs by the photoionization of atomic oxygen, atom-ion exchange between these ions and either molecular oxygen or molecular nitrogen, and finally dissociative recombination of the resulting molecular ions with electrons. Other recombination processes have small rates compared with dissociative recombination and can be ignored. Ionization of molecular nitrogen can be ignored since the density of molecular nitrogen is probably small and the molecular nitrogen ion recombines much more rapidly than the atomic oxygen ion.

Then, where transport of charge is unimportant, the ion and electron densities in the F2 region are governed by the three continuity equations for the atomic oxygen ion, the molecular ion and the electron density, which forms a system of three coupled differential equations.

This system of equations has been integrated in two ways: first, analytically by assuming that the density of the molecular ion is in quasi-steady state, and second, numerically. Comparison of the two solutions shows that the assumption leading to the analytic solution is almost always valid. The solution for the electron density is compared with daytime electron density profiles from a station on the magnetic equator, since there vertical transport of charge is inhibited by the magnetic field. With fast photochemical rates and a neutral atmosphere which varies in time due to the diurnal variation of atmospheric temperature, satisfactory agreement between theory and observations is obtained.

A

NUPEN. W. Bibliography on ionospheric propagation of radio waves. NBS Tech. Note 84, National Bureau of Standards, Boulder, Colo. (Oct. 1960).

Some of the material used in this Bibliography was submitted to the Abstracts group by the Boulder Laboratories of the National Bureau of Standards. However, the vast majority of the papers referenced in the Bibliography have been written since 1950. The reader interested in a fuller coverage of ionospheric propagation of radio waves prior to 1950 is referred to Dr. L. A. Manning's bibliography entitled "A Survey of the

Literature of the Ionosphere", dated July 31, 1955 of the Radio-science Laboratory of Stanford University; or "The Upper Atmosphere", by Dr. S. K. Mitra published in 1952 by the Asiatic Society, and to other standard works.

Several distinct fields of ionospheric propagation have been purposely omitted in order to keep the volume of material down to manageable proportions. There are:

Meteor or meteor trail propagation
Radio reflection from auroras
Radioastronomy

These, and related aspects, will be the subjects for a smaller supplementary volume; and the accumulated literature on Tropospheric Propagation for still another volume, also of somewhat smaller dimensions.
Excerpt.

NUPEN, W. Bibliography on atmospheric aspects of radio astronomy. NBS Tech. Note 171, National Bureau of Standards, Boulder, Colo. (1 May 1963).

This is the fourth in a series of bibliographies being prepared by the M & GA staff of the American Meteorological Society for the Boulder Laboratories of the National Bureau of Standards. The first three were:

1. Bibliography on Ionospheric Propagation of Radio Waves (1923-1960). NBS Technical Note No. 84, October 1960. (1404 items)
2. Bibliography on Meteoric Radio Wave Propagation. NBS Technical Note No. 94, May 1961. (368 items.)
3. Bibliography on Auroral Radio Wave Propagation. NBS Technical Note No. 128, January 1962. (297 items)

The present bibliography on Atomospheric Aspects of Radio Astronomy Including Selected References to Related Fields contains over a thousand abstracts or titles taken from the literature published between 1900 and 1961, incl., but the bulk of the literature follows the discovery by Jansky in 1932 of radiofrequency radiation from the sun, and especially the building of radio telescopes since World War II.

The subject matter in this bibliography is confined to the effects of the earth's atmosphere on radiofrequency radiation from the sun, planets, stars, the galaxies and intergalactic space, or knowledge of atmospheric or ionospheric structure, composition, or physics.
Excerpt

N. Y. U. Theoretical studies on the propagation of electromagnetic waves, including problems of reflection, refraction and diffraction. Progress Report, 1 January - 21 March 1951, Contract AF 19(122)-42, Mathematics Research Group, Washington Square College, New York University (n. d.).

This report summarizes the research activities in the theory of electromagnetic propagation by the Mathematics Research Group of Washington Square College of Arts and Science associated with the Institute for Mathematics and Mechanics at New York University for the ninth quarterly period under Contract AF-19(122)-42. During this period three Research Reports were submitted. Abstracts of these reports are included. A complete listing of the reports, publications and other scientific activities of members of the group in connection with work done under this contract is included in Sec. 2. Activities in connection with publication of the Proceedings of the Symposium on the Theory of Electromagnetic Waves sponsored jointly by the University and the Geophysical Research Directorate are described in Sec. 2.4. In Sec. 3 the status of current research activities are discussed. Various administrative measures are detailed in Sec. 4.
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OBAYASHI, T. On the world-wide disturbance in F2-region. J. Geomag. Geoelec. 6, 57-67 (1954).

The world-wide patterns of the F2-region disturbance and their development process with the geomagnetic storm-time were examined with the comprehensive world-wide data of F2-layer.

The average disturbance in f^0F2 during the main phase of the associated magnetic storm, so-called $D(f^0F2)$, was derived with respect to geomagnetic latitude and local-time, and it was separated into the $Dst(f^0F2)$ and $Ds(f^0F2)$ component. It will be shown in this analysis these two components play an important role in the ionospheric storms, and not only their range, but also their phase are controlled by the magnetic activity.

The average development course of the ionospheric storm and the mode of the $Ds(f^0F2)$, changing regularly with storm-time, were studied. The phase of the $Ds(f^0F2)$ during the active stage of magnetic storm is almost uniquely dependent upon local-time, but after the activation ceases, the pattern of the disturbance moves together with the rotating earth.

Detailed analysis was made on the progressive aspects of the individual disturbances in the northern hemisphere accompanied with some typical severe magnetic storms.

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OBAYASHI, T., and J. A. Jacobs. Sudden commencements of magnetic storms and atmospheric dynamo action. J. Geophys. Res. 62, 589-616 (July 1957).

A statistical investigation of world-wide sudden commencements of magnetic storms has been carried out using data from over 30 magnetic observatories distributed all over the world. An appreciable diurnal change in the amplitude of SC's has been found, and the average electric current system for the Ds field shows conspicuous current concentrations in the polar regions. The pattern of this current system is similar to that caused by an electric doublet centered on the highly conducting region near the geomagnetic pole, and hence it is probable that the current system exists within the earth's atmosphere. On the other hand, the Dst field of SC's seems more likely to be of extraterrestrial origin.

An atmospheric dynamo theory has been applied to interpret this Ds current system, on the assumption that the main source of electromotive force generation is due to the enhancement of electrical conductivity in the polar region. The change at a SC is so abrupt (within a few minutes) that it is reasonable to assume that the wind system in the ionosphere will not change. Thus, using the wind system estimated from the Sq field, the current system at the time of commencement of the storm has been computed, assuming an appropriate change in the electrical conductivity. Good agreement with observed results has been obtained, and it suggests

that a dynamo action in the upper atmosphere is the dominant cause of geomagnetic variations during disturbances. Moreover, there has been found a consistent wind system which can produce the observed geomagnetic variations both for quiet and disturbed conditions with a reasonable range of conductivity changes in the polar regions. This wind system consists of both a diurnal and a semidiurnal term, and the estimated order of magnitude agrees with recent ionospheric measurements.
A

OBAYASHI, T. Polar ionospheric disturbances associated with a severe magnetic storm. J. Geomag. Geoelec. 10, 28-35 (1958).

A detailed investigation is made of a severe magnetic storm on 28 October, 1951, using world-wide simultaneous geomagnetic and ionospheric data. It has been found that an outstanding electrojet stream, comparatively short-lived, appeared near the southern edge of the auroral zone at the end of the main phase of this storm. The ionospheric disturbance associated with this electrojet was anomalous; the electron density of the F2-layer above the electrojet stream increased suddenly to more than 10^6 electrons/cm^3 and then dropped below normal after the disappearance of the current stream. Although no existing theory of ionospheric storms can explain satisfactorily this anomalous change, two possible mechanisms are suggested from consideration of the direct association of geomagnetic and ionospheric variations. One is the effect of the incoming corpuscular precipitation into the ionosphere and the consequent formation of a new F2-layer due to the increase of ionization. The other is due to the vertical drift of electrons produced by the interaction of the geomagnetic field with the currents in the F2-region returning from the main electrojet formed in the E-region.
PA

OBAYASHI, T. A possibility of the long distance HF propagation along the exospheric field-aligned ionizations. J. Radio Res. Labs. 6, 603-612 (July 1959).

Transequatorial very long range echoes of the order of 7000 km detected by HF backscatter sounder at Hiraiso are interpreted as the ground backscatter propagation launched on the path along the exospheric field aligned ionizations. Ray path calculation on this longitudinal mode of propagation between the geomagnetically conjugate points along its field line is made for various geomagnetic latitudes. The expected echo distance agrees well with that of obtained by the experiments. It is also found that the average exospheric electron density deduced from the observed echo spreads is about 10^4 - 10^6 electrons per cm^3. A possible use of this propagation mode of backscatter as a tool of exospheric sounding is suggested.
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OBAYASHI, T. The S.I.D. effect on V.H.F. scatter propagation associated with the great solar outburst of 29 July, 1958. IN: Beynon, W. J. G., ed. Some Ionospheric Results Obtained During the IGY, Proc. Symposium URSI/AGI Committee, Brussels, Sept. 1959, 137-138 (Elsevier Publishing Co., New York 1960).

It has been known that the radio signal at v.h.f. by scattering propagation in the lower ionosphere is slightly enhanced at times of S.I.D.'s in the h.f. band. Since the scattering region in the ionosphere for the v.h.f. long distance transmission is below the usual S.I.D.'s producing layer (80-100 km), this effect at v.h.f. could be explained by the fact that the v.h.f. radio waves do not suffer as much attenuation in the ionosphere as do h.f., but are enhanced owing to the increase of electron density in the scattering volume during S.I.D.'s.

A new transmission route of the v.h.f. (49.68 Mc/s) to study the ionospheric forward scatter propagation was established in 1957 between Okinawa and Hiraiso (distance 1600 km) with the cooperation of the C.R.P.L., U.S., and the Radio Research Laboratories, Japan. Although there had been several large solar radio outbursts since November 1957, none of them was observed to produce any appreciable change except the great solar outbursts of July 29, August 16 and 26, 1958. Those three events were accompanied by solar flares of importance 3+, and were characterized by remarkable fadeouts of v.h.f. sky waves.

The present brief note concerns this new evidence of v.h.f. sky wave fade coincident with the unusual solar flare on July 29, 1958. An intense solar outburst was observed at the frequency of 200 Mc/s and the accompanying S.I.D. at 20.82 Mc/s (San Francisco-Hiraiso Route). A sudden enhancement of solar radio emission (the first part of the solar outburst) took place at 0305 h (U.T.), the flux density exceeding 20,000 x 10^{-22} W.M.$^{-2}$ (c/s)$^{-1}$. The duration of the first part was about 20 minutes and this was certainly one of the greatest solar outbursts ever recorded. The S.I.D. effect in h.f. band was also a typical one. Radio waves of all long distance h.f. transmission suffered a great attenuation from a few minutes after 0300 h to about 0400 h (local time, 1200-1300 h).

The record of 49.68 Mc/s ionospheric scatter propagation is reproduced in Fig. 1. A marked decrease of the received field intensity commenced at 0303 h and waves faded out below the noise level till about 0320 h, the maximum depression of the intensity was more than 40 db. It is very interesting to note that, during the course of the S.I.D., a distinct rise of noise level was observed from 0308 to 0312 h. This phenomenon may be due to a direct effect of the solar radio outburst. The time difference between the outburst at 200 Mc/s and this is about 3 minutes and of the correct order if it is assumed that this outburst is of type 2 (slow drift type).

It is generally believed that the S. I. D. producing layer is formed around 80-100 km by a sudden enhancement of the coronal soft X-ray radiation. However, the scattering region of v. h. f. long distance propagation is situated about 70-80 km, and this height is usually below the S. I. D. producing layer. Hence, to explain the above-mentioned fadeout effect at v. h. f., a further hardening of the coronal X-ray spectrum must be assumed during a great solar flare.
A

OBAYASHI, T. Ionospheric radio propagation disturbances caused by high-altitude nuclear explosions. IN: Beynon, W. J. G., ed. Some Ionospheric Results Obtained During the IGY, Proc. Symposium URSI/AGI Committee, Brussels, Sep. 1959, 139-141 (Elsevier Publishing Co., New York, 1960).

Considerable attention has been given recently to the geophysical effects of the high-altitude nuclear tests carried out in August, 1958, at Johnston Island in the Pacific. One test was made 1051 U. T. on August 1 at a height of about 150 km, and the other at 1030 h U. T. on August 12 at rather a lower height than the former. Observations at Apia, Samoa, showed that the test on August 1 coincided with the appearance of an aurora. The special significance of this is that Apia and Johnston Island lie approximately at opposite ends of a geomagnetic line of force, and this would suggest that any effects are largely restricted to the vicinities of the two ends of the line of force. However, it is the purpose of this note to present evidence strongly suggesting that increased D layer ionization and also presumably the disturbance in the F_2 layer occur for distances far greater from the explosion than has hitherto been realized, and at places remote from either the explosion or its geomagnetic conjugate.
Excerpt

OCHS, G. R., D. T. Farley, K. L. Bowles, and P. Bandyopadhay. Observations of synchrotron radio noise at the magnetic equator following the high-altitude nuclear explosion of 9 July, 1962. J. Geophys. Res. 68, 701-711 (1963).

This paper describes the results of radio measurements made in Peru of synchrotron radiation at 30 and 50 Mc/s. This radiation was produced by relativistic electrons injected into trapped orbits in the earth's magnetic field during the high-altitude nuclear explosion of July 9, 1962. A preliminary interpretation of these results is also given. At 50 Mc/s there was a brief

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transient increase in the antenna temperature of 4.5×10^4 °K shortly after the explosion. This can be compared to the normal antenna temperature at that time of 5.5×10^4 °K. The excess temperature soon decreased to about 1×10^4 °K and has since decayed only very slowly from this value, the time constant being about two months. From the early transient changes in the antenna temperature, a fairly accurate description of the energy distribution of the electrons is obtained. This spectrum is found to vary almost exactly as the fission spectrum, $\exp(-0.575E - 0.055E^2)$, in the range $1 \leq E \leq 5$, where E is the kinetic energy in Mev. Above 5 Mev the spectrum falls off somewhat faster than this expression, but the measurements are rather poor in this range. The value 2×10^{24} is obtained as a rough estimate of the total number of electrons having energies of the order of 1 Mev or greater that were trapped after the explosion.
A

OGBUEHI, P. O., and A. Onwumechilli. Recent measurements of the magnetic field of the equatorial electrojet in Nigeria. J. Geophys. Res. 68, 2421-2424 (1963).

Photographic records of the daily variations of the magnetic elements H, D, and Z were taken at 10 stations across the magnetic zero dip equator in Nigeria around the June solstice (May to July) 1962. A preliminary analysis of these records locates the axis of the equatorial electrojet on the magnetic equator (10.2° N latitude in Nigeria), and there the average daily range of Z was practically zero. On the model of a uniform current band at a height of 110 km the equatorial electrojet in this season was found to have a width of (406 ± 20) km and a current intensity of 116 amp km^{-2}. These values are compared with other existing values; they show clearly that both the width and the intensity of the electrojet have decreased with decrease in solar activity.
A

OGUTI, T. On the Earth storms. 5. Interrelations among the upper atmosphere disturbance phenomena over the polar regions. Rept. Ionosphere Space Res. Japan 14, 291-300 (1960).

Interrelations among the upper atmosphere disturbance phenomena in the auroral zone are discussed with the aid of observation at Syowa Station (69° 00'S, 39° 35'E). Results obtained can be summarized as follows: 1) Geomagnetic bay type disturbances, ionospheric disturbances represented by anomalous increase in fEs and blackout and abrupt increase of auroral luminosity λ 5577 in zenith begin simultaneously with each other within the accuracy of observation. It is noteworthy that the onset of increase of auroral zenith luminosity not of total activity is simultaneously with those of the other disturbance phenomena. 2) Ionospheric balckout follows geomagnetic disturbances and auroral displays in morning day time site of the auroral zone, while increase in fE_s follows those in evening night time site. 3) Numerical values representing activity of disturbances i.e., decrease of geomagnetic horizontal intensity, increase in fE_s and auroral λ 5577 zenith intensity are found to be consistent with each other, if it is postulated that these disturbance phenomena are due to anomalous ionization in the lower ionosphere with simultaneous excitation during auroral displays. 4) From the observed facts mentioned above, these disturbance phenomena may be tentatively interpreted by postulating that they are all derived from impinging particles into the upper atmosphere in the auroral zone.
MGA

OKAMOTO, H., M. Ose, and K. Aida. New type of scattering echo observed by the shipborne ionospheric sounder over the sea. Rept. Ionosphere Res. Japan 11, 50-54 (1957).

On the first Japanese Antarctic research expedition (1956-7) from Japan to Singapore to Cape Town to Syowa Base and return, a new type of ionospheric sounding echo scattering was observed (as shown on recorder records) in a region up to 120 km above the surface for h'f records. No internal or instrumental failure could be found and, as shown on an hourly graph, a diurnal cycle was predominant (scatter mostly in daytime). Over-sea, land or ice propagation showed differences in type of scatter, being weaker over land or ice than over sea. It apparently is due to tropospheric conditions.
N

ONDOH, T. Ionospheric currents responsible for sudden commencements observed at the geomagnetic equator. J. Geophys. Res. 66, 4155-4161 (1961).

The intensities and altitudes of ionospheric currents responsible for sudden commencements at the geomagnetic equator are calculated by using the horizontal and vertical disturbance vectors of the sc's observed simultaneously at the Jarvis and Fanning Island stations, on the assumption either that these currents are line currents or that they are uniform current sheets. The result shows that the total intensity of the current responsible for the sc is of the order of 10^4 amperes at the geomagnetic equator, and that there is no relation between the altitude of the current responsible for the sc and the local time of the occurrence. It seems likely that this current is caused by the arrival of hydromagnetic waves generated by the impact of the solar plasma cloud on the geomagnetic field. Possible explanations for the daytime enhancement of the amplitude of the sc at the geomagnetic equator are discussed.
A

ONWUMECHILLI, C. A. Possible asymmetry in the daily range of the geomagnetic vertical intensity around the magnetic equator. Nature 184, 51 (1959).

Contrasts briefly results from two magnetic observatories straddling the equator as a means of detecting an asymmetry in the vertical intensity on opposite sides of the equator.
PA

ONWUMECHILLI, (C.) A. A study of the equatorial electrojet-I. An experimental study. J. Atmos. Terrest. Phys. 13, 222-234 (1959).

An account is given of the photographic registration of the variation of the earth's horizontal magnetic force (H) across the magnetic equator in Nigeria from November 1956 to January 1957. As the period was magnetically quiet and the records were good, it has been possible to make a detailed study of the quiet day variation. The latitude of the maximum range of H was found to be about 0.5° from the magnetic towards the geographic equator. The daily variation curve of H is found to change its form as the magnetic equator is crossed from south to north and a method is introduced for the study of this change. It is shown that the fluctuations in H-variation curve characteristic of equatorial stations occur at the same time and in the

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same form at equatorial stations that may be distant from one another. The magnitudes of the same fluctuation at two stations are in about the same ratio as the daily ranges at the stations. It is thus likely that the indentations in the H-variation curve arise from fluctuations in the ionizing agent from the sun.
A

ONWUMECHILLI, C. A. A study of the equatorial electrojet-II. A model electrojet that fits H-observations. J. Atmos. Terrest. Phys. 13, 235-257 (1959).

Methods are developed for separating the observed variation of the horizontal magnetic force (H) into its two component parts - the effect of the equatorial electrojet and the "normal variation" without the electrojet. It is shown that in such a separation, it is necessary to allow for the possible phase difference between the two component parts. Theoretical curves from the electrojet regarded as a horizontal current band of uniform intensity are found to fit the experimental points reasonably well. The electrojet is found to have a height of from 100 to 125 km, a width of 4° latitude and the current intensity at the height of 100 km is 6700 A/degree latitude. The effect of the electrojet on the vertical component (Z) of the earth's magnetic field is found to have a maximum value at about 250 km from the jet.

It is shown that after 600 km from the electrojet, the H-effect of the jet becomes very small whereas the Z-effect is large enough to explain the large Z-ranges observed in such regions. The geographical distribution of the forms of H-variation curve across the magnetic equator is explained as a result of the superposition of the "normal" variation and the electrojet effect. It is pointed out that Z-ranges observed at various parts of the world near the magnetic equator indicate a lack of symmetry about that equator and this is explained with a theory developed in this paper. Some suggestions are given about the relative importance of the geographic, magnetic, and geomagnetic equators in geomagnetic variation.
A

ONWUMECHILLI, (C.) A., and N. S. Alexander. Variations in the geomagnetic field at Ibadan, Nigeria-I. Solar variations. J. Atmos. Terrest. Phys. 16, 106-114 (1959).

Magnetic records obtained at the recently established magnetic observatory at Ibadan in equatorial Africa for the period November 1955 to June 1957 are analysed harmonically for solar variations. The results, given in the form of harmonic dials, show that the amplitude of H is very large (similar to that observed at Huancayo), and the amplitude of Z is larger by a factor of 3 than any previously reported. These results are explained as arising from the equatorial electrojet centered on the magnetic

equator, which is about 2 1/2° N of Ibadan. The variation in D at Ibadan is small, but has its phase completely reversed between the June and December solstices. The d-variation shows no obvious effect of the electrojet.
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ONWUMECHILLI, C. A. and N. S. Alexander. Variations in the geomagnetic field at Ibadan, Nigeria-II. Lunar and luni-solar variations in H and Z. J. Atmos. Terrest. Phys. 16, 115-123 (1959).

Magnetic records obtained from November 1955 to June 1957 at Ibadan, Nigeria, have been analysed harmonically for lunar and luni-solar variations. The results are statistically significant. The L-variations in H and Z are abnormally large at Ibadan. The L-variation in H is comparable with that of Huancayo and about three times greater than at other observatories of comparable geographic latitude. The L-variation in Z is larger than any previously reported. These results are explained as the effect of the equatorial electrojet. The ratio of S to L in H is small at Ibadan as at Huancayo. S/L in Z is equally small at Ibadan (Ibadan happens to be near the latitude where the Z effect of the electrojet is a maximum (Onwumechilli, 1959). The Chapman (1913) expression for L is fully confirmed in all aspects.
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ONWUMECHILLI, C. A. The relation between H- and Z-variations near the equatorial electrojet. J. Atmos. Terrest. Phys. 16, 274-282 (1959).

The parallelism in the variations of the geomagnetic horizontal component (H) and vertical component (Z), so obvious in the magnetograms of Ibadan, has been investigated. During day-time when the effect of the electrojet is dominant, H and Z vary proportionately. Numerous indentations of varying period and amplitude are a prominent feature of day-time variation curves of H and Z at Ibadan. Six hundred of these indentations have been measured and analysed. The indentations attain their maximal values simultaneously in H and Z. Within the limits of experimental error, in 86 percent of the cases during the day and 54 percent of those during the night, the indentations also begin and end simultaneously in H and Z.

The ratio of r of the amplitude of an indentation in H to the amplitude of the same indentation in Z exhibits a remarkable diurnal variation, being constant for most of the day-time. The average value is 2.114 ± 0.021 during daytime and 4.112 ± 0.095 during the night. The ratio r is surprisingly independent of magnetic disturbance but decreases with increase in the period of duration T. For indentations of short periods T (e.g. not exceeding 15 min) the ratio r equals the ratio R of the diurnal range of H to the range of Z on undisturbed days. It is suggested that the indentations

are caused by fluctuations in the quantity and quality of ionizing agents from the sun and that the decrease of r with increase in T is associated with vertical movements of the E-layer of the ionosphere (or the S_q-layer).
A

ONWUMECHILLI, (C.) A. Fluctuations in the geomagnetic horizontal field near the magnetic equator. J. Atmos. Terrest. Phys. 17, 286-294 (1960).

Six-hundred fluctuations in the geomagnetic horizontal component (H) and vertical component (Z) have been measured from the magnetograms taken at Ibadan in April and May 1958. An analysis of these has shown that: (a) the frequency of occurrence varies with local time in the same ways as S_q; (b) the amplitude of fluctuations increases in a general way with S_q; (c) the amplitude of fluctuations in both H and Z tend to increase linearly with period in duration (T) and there is some evidence for a change of slope at about T = 33 min with the fluctuations of longer duration increasing more slowly with T than those of shorter duration; (d) fluctuations under quiet conditions occur mostly during day-time and are more frequent when S_q is high; (e) fluctuations during the night are of long duration and mostly occur during disturbance ($K_p > 3+$). It has been shown that fluctuations under quiet conditions have the characteristics of solar-flare effects and it is therefore suggested that both arise from similar causes.
A

ONWUMECHILLI, (C.) A. Lunar daily variation of the magnetic declination at Ibadan, Nigeria. J. Geophys. Res. 65, 3433-3435 (1960).

The data taken for 52 months at Ibadan are analyzed for lunar variation in geomagnetic declination (D). When grouped according to seasons, the results are found to be statistically significant for the June and December solstices but not for the equinox. There is almost a complete reversal of phase between the variations in the two solstices. It is found that the lunar variation in D at Ibadan does not show the marked effect of the equatorial electrojet so clearly observable in the variations of the horizontal force (H) and the vertical force (Z). Surprisingly, however, the amplitude of variation in the summer is slightly smaller than that of the winter, but it is not yet clear how far this anomaly can be attributed to the electrojet.
A

ONWUMECHILLI, (C.) A., and P. O. Ogbuehi. Fluctuations in the geomagnetic horizontal field. J. Atmos. Terrest. Phys. 24, 173-190 (1962).

We have studied the spatial distribution of the incidence and amplitude of fluctuations in the geomagnetic horizontal field in the range of a few

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gammas to about 50γ ($1\gamma = 10^{-5}$ gauss) and in duration from a few minutes to about 2 hr, and found that: (a) almost all the fluctuations observed at the equatorial observatory at Ibadan are identificable under favourable conditions up to +60° geographic latitude and are very likely world-wide; (b) the amplitude of fluctuations is sensitively dependent on local time and the strength of S_q current; (c) the amplitude of fluctuations is enhanced by about the same factor as $S_q(H)$ at the magnetic zero dip equator and reaches a maximum at the same place as $S_q(H)$ under the equatorial electrojet; (d) neither the ratio of the amplitudes of a fluctuation in H at two observatories nor the ratio of the fluctuation in the two magnetic elements H and Z at Ibadan is affected by the intensity of magnetic disturbance.

It is argued that no existing theory gives a completely satisfactory cause of geomagnetic fluctuations in the low latitudes. A hypothesis requiring the emission of radiation as incoming plasma suffers some interaction at the outer fringes of the earth's upper atmosphere is tentatively suggested.

It is suggested that the diurnal variation of the frequency of occurrence of sudden commencements and sudden impulses could be explained from the diurnal variation of their amplitude.

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ONWUMECHILLI, (C.) A. Lunar effect on the diurnal variation of the geomagnetic horizontal field near the magnetic equator. J. Atmos. Terrest. Phys. 25, 55-70 (1963).

Lunar effect on the diurnal variation of the geomagnetic horizontal field (H) at Ibadan has been investigated using magnetograms of 28 months all in the season of Northern Winter. It has been found that lunar tide (L) accounts for about 11 percent of the daily range of H and its contribution to the departure of the hourly mean of H is about 14 percent at 11 hr, 17 percent at 13 hr, and 36 percent at 16 hr local time at Ibadan. The assymmetry of the diurnal curve of H is found to be independent of L. A new method is described for estimating the intensity of the L-field at certain hours on individual days and this has shown that the ratio of intensities of L to S varies from hour to hour on the same day. The existence of "Big-L-days" reported by Bartels and Johnston (1940) is found to be doubtful. Evidence has been brought to show that if the existence of Big-L-days is accepted, then the existence of "Small-L-days" and "Inverse-L-days" also has to be accepted.

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ONWUMECHILLI, (C.) A. Separation of the semidiurnal tidal effect on individual days and some equatorial features of the geomagnetic lunar tide. J. Geophys. Res. 68, 2425-2433 (1963).

A method of estimating the lunar effect on individual days is reported. Calculations are carried out to demonstrate how it may help in the study of some aspects of the L field. The contribution of the L field to the diurnal variation of the geomagnetic horizontal field (H) at Ibadan is found to be large, but it is not clear whether 'big-L days' of the type reported by Bartels and Johnston [1940] from Huancayo really exist. The evidence is such that, if the existence of big-L days is accepted, the existence of small-L days and even inverse-L days has to be accepted. The results rather indicate that the magnification of L may vary from hour to hour on the same day. The asymmetry in the variation of H near the magnetic equator (defined by Onwumechilli [1959]) is found not to arise from the L field.
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OSBORNE, B. W. Ionospheric behaviour in the F_2 region at Singapore J. Atmos. Terrest. Phys. 2, 66-79 (1951).

Previous work on ionospheric behaviour at low latitudes has demonstrated the existence of ionospheric phenomena peculiar to equatorial regions, particularly during the midday period and after sunset, within the region of a "trough" of low F_2 layer critical frequency near the magnetic equator. Observations at Singapore (on the southern edge of this "trough") from November 1948 have shown the inter-dependence of F2 layer critical frequency and height with the seasonal occurrence of thick layer effects. Ionospheric behaviour at Singapore during the December solstice shows marked differences from that at the equatorial station of Huancayo, Peru, during daylight hours. Layer height changes after sunset, and the associated occurrence of the equatorial scatter phenomenon, are discussed. Consideration is given to the interpretation of vertical incidence virtual height measurements under Singapore conditions of a thick F region.
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OSBORNE, B. W. Some practical determinations of electron content below the level of maximum ionization in the F_2 region of the ionosphere. J. Atmos. Terrest. Phys. 3, 58-67 (1952).

This paper describes an investigation of the variation in the total number of electrons, n, in a vertical column of unit cross-section in the F_2 region of

the ionosphere up to the level of maximum ionization with the solar zenith angle χ at Slough and Singapore during selected days in every month of 1949; and at Singapore and Penang during a programme of simultaneous observations made at the two stations in July 1949.

The seasonal and diurnal variations of maximum electron density differ from those in n, the latter showing a greater dependence on cos χ. Several anomalies are, however, still evident.

Diurnal variations in the latitude gradient of n near the magnetic equator are briefly discussed. It appears probable that, as the latitude is altered, the local noon value of n goes through a flat maximum in equatorial latitudes, whereas the noon value of maximum electron density goes through a sharp minimum near the magnetic equator, and exhibits the well-known "equatorial trough".

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OSBORNE, B. W. Note on ionospheric conditions which may affect tropical broadcasting services after sunset. J. Brit. Inst. Radio Engrs. 12, 110 (Feb. 1952).

While reliable reception between sunset and midnight is of considerable program value, there are certain ionospheric phenomena, peculiar to neighborhood of magnetic equator, which can cause intolerable fading over short paths involving reflection at F2 layer; scattering phenomena at such places as Singapore.

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OSBORNE, B. W. Lunar variation in F_2 region critical frequency at Singapore. Nature 169, 661-662 (1952).

The existence of large lunar tidal effects in the F_2 region of the ionosphere at latitudes near the magnetic equator has been demonstrated by Martyn, and by McNish and Gautier, at Huancayo and elsewhere. It was found at Huancayo that minima in the ordinary-ray critical frequency for the F2 region, f_0F2, occurred at the times of greatest amplitude of the diurnal variation in the earth's horizontal magnetic field, that is, about four days after the new and the full moon.

In this communication, the relation is considered between the midday values of f_0F2 at Singapore and the age of the moon over the period from November 1918 to June 1951 inclusive, for which a continuous series of observations was available. As ionospheric conditions at Singapore are noticeably different at the December solstice, the equinox months and the June solstice, it is natural to treat these periods separately. Furthermore, the same periods have been considered in the Huancayo analysis, with which the results obtained from Singapore may be compared. In order to obtain sufficient results for each day of the moon's age, the values of

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f_0F2 at 1100, 1200 and 1300 hr. local mean time were grouped together, and minor fluctuations smoothed out by using three-day running mean values. The results of this superposed epoch analysis are shown in Figs. 1(a), (b) and (c) for the December solstice, the equinox and the June solstice respectively. A minimum in f_0F2 a few days after the full moon is clearly evident at these times of the year, while during the June solstice there is also a well-marked minimum after the new moon. Comparison with the results given for Huancayo shows that the amplitude of the Singapore equinoctial variation for this period near sunspot maximum is approximately half that obtained at the equinoxes at Huancayo during 1941-44, a period near sunspot minimum.

A lunar control of the times of appearance of ledges in the upper F_2 region has been suggested by McNish. Ledges in the F_2 region have been observed for several years at Singapore at heights up to about 800 km., particularly before noon during the December solstice and, to a lesser extent, after noon during the June solstice. These ledges are characteristically restricted to periods when a thick F_2 layer is present. In order to ascertain whether the occurrence at Singapore of a thick layer and formation of a ledge were in any way associated with the moon, the values of f_0F2 for the three hours centered on 1000 L. M. T. for the December solstice, and centered on 1400 L. M. T. for the June solstice, were examined in a similar manner. It should be mentioned that there was no large diurnal change in the monthly mean values of f_0F2 over the hours which were grouped together for the purpose of this analysis. The results obtained are shown in Figs. 2 (a) and (b) for the December and June solstices respectively. Comparison of Fig. 2 (a) with Fig. 1 (a) shows that the lunar variation of f_0F2 in the December solstice for the hours centered on 1000 L. M. T. is more than twice as great as that obtained at midday, and there is a noticeable minimum after the new moon which was not previously evident. The maxima at the first and last quarters are well marked, and the whole lunar cycle is distinct. For the June solstice, comparison of Fig. 2 (b) with Fig. 1 (c) shows no significant increase in the amplitude of the lunar component, through the former figure, for the hours after noon, displays a more pronounced full moon minimum.

The data used for constructing the curves in Figs. 1 and 2 include all values of f_0F2 obtained at the relevant hours, except for those very few values which were marked as affected by storm conditions. It may be mentioned, however, that at some hours ionospheric behaviour and conditions of measurement were such that no value of f_0F2 could be tabulated.

It may be concluded that, at Singapore, the moon exerts an influence on the structure of the upper F_2 region, and thus modifies the value of f_0F2. An adequate theoretical explanation of the very large ionospheric variations produced is not yet available.

Excerpt

OSBORNE, B. W. The electron content of the F_2 layer above Singapore.
J. Atmos. Terrest. Phys. 4, 82-84 (1953).

In this note we compare the total ionization present in a unit column, n, below the level of maximum ionization density of the F_2 layer in 1949, a year of great solar activity (R ~ 120), and in 1952, a year of slight activity (R ~ 30). The total electron content, n, is estimated by parabolic methods (Osborne, 1952a, Ratcliffe, 1951) for six equally spaced days in June and December 1952, and the results are compared with similar data for the corresponding months of 1949 (Figs. 1, 2).

The diurnal variations of "n" are reasonably consistent with the hypothesis that the ions are produced by photo-ionization in a medium with an appreciable ionization relaxation time. Perturbations due to movements of ionization, which dominate the corresponding curves for f_0F_2, modify the shape of the curves for 1949 but are comparatively small in 1952. Thus the large anomalous differences between June and December evident in sunspot maximum years have largely disappeared.

It is interesting to compare these results with those obtained by Ratcliffe (1951b) for Huancayo, Alaska and Watheroo.

The midday values of n at Singapore at sunspot maximum are very similar to those obtained by Ratcliffe (1951) for Huancayo; and it is suggestive that the values of n at Singapore during the early morning ($\chi > 60°$) in 1952 are consistent with those found at Alaska and Watheroo for similar values of χ, again implying that transport of ionization is comparatively unimportant at these times.

The small change in "n" at Singapore between 1949 and 1952, and the differences between the shapes of the diurnal curves in 1949 and 1952, which are particularly noticeable during the December solstice (see Fig. 2), appear to be due (McNish, 1950; Osborne, 1952b) to ionization moving above the level of maximum ionization density in years of great solar activity. Ratcliffe (1951b) however claims that this phenomenon is most evident at Huancayo in years of minimum solar activity, though McNish has observed its presence there during sunspot maximum (1939) also.
Excerpt

OSBORNE, B. W. Horizontal movements of ionization in the equatorial F-region.
J. Atmos. Terrest. Phys. 6, 117-123 (1955).

Spaced-aerial observations of horizontal velocity of ionized particles during day in F region at Singapore gave in Sept.-Oct. 1953 a regular semidiurnal variation from about 52 m/s towards E at 9-12 h LMT to nearly 50 m/s towards W at 15-17 h. A doubtful tendency was found for movement to S at 9-15 h. In Nov. 1953-Feb. 1954 movements were less regular and mostly towards W from 10-18 h. In March-April 1954 variation

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was from 40-50 m/s towards E at 9 h and 23 h to over 50 m/s towards W at 17 h.
MGA

OSBORNE, D. G. Equatorial electrojet in Ghana. Nature 193, 567-568 (1962).

A study of the recordings from an Askania magnetograph at Tamale, 39 km south of the magnetic (zero dip) equator, has shown that the mean position of the equatorial electrojet at the time of daily maximum of jet intensity is 14 ± 8 km north of the magnetic equator in that locality. The relative changes in the horizontal and vertical components of the magnetic field as recorded at Tamale show that, on the model used for the calculations, the jet changes position as well as intensity. The r. m. s. of displacement of the jet axis from its mean position was about 46 km over the period studied.
PA

OSBORNE, D. G. Position and movement of the equatorial electrojet over Ghana. J. Atmos. Terrest. Phys. 24, 491-502 (1962).

Measurements of absolute vertical field in order to locate the magnetic equator and of diurnal variation at two stations near this equator are described and interpreted. It is shown that the observed variability of the diurnal variation can be explained by supposing changes from day to day in the position and strength of the electrojet. The mean position of the jet axis lies very close to the magnetic equator for the period February and March 1961, but the axis moves from one day to another with a root mean square displacement of 46 km. The lack of dependence of jet strength of the normal current system introduces considerable errors in estimates of magnetic variation based on supposedly fixed ratios between non-equatorial and equatorial stations.
PA

OSBORNE, D. G. Daily variability in strength of the equatorial electrojet. J. Geophys. Res. 68, 2435-2439 (1963).

Values are deduced for the contributions to the diurnal range of the horizontal magnetic component by the normal S_q current system and the equatorial electrojet. Both contributions vary much from day to day, but there is only a weak correlation between the two. Hence it is suggested

that in analyzing magnetograms ranges should not be 'normalized' by taking ratios for different stations near the magnetic equator. It is also argued that the electrojet cannot be a simple enhancement of the normal current in a belt of high conductivity. Evidence is given for a slight decrease in electrojet strength on magnetically disturbed days.
A

OSBORNE, D. G., and N. J. Skinner. Equatorial drift and the electrojet. J. Geophys. Res. 68, 2441-2444 (1963).

Apparent horizontal east-west drift velocities in the F layer have been measured near the magnetic equator at Tamale in northern Ghana by the spaced-receiver, pulse-fading method. These velocities are compared with changes in the horizontal magnetic field strength in the daytime. It is shown that the drift velocity is closely related to the current strength in the equatorial electrojet and that it increases when the jet current increases.
A

OSE, M., K. Aida, and H. Okamoto. Latitude dependence of f_0F2 over the range of 20°N to 69°S, obtained by ship-borne ionospheric sounder. J. Atmos. Terrest. Phys. 15, 130-131 (1959).

On the occasion of the first expedition of Japanese Antarctic Research 1956-1957, routine ionospheric sounding was carried out all the way by the shipborne sounder on board the Soya.

The sounding began on 11 November 1956, at the southernmost part of Japan and lasted until the ship came back there on 21 April 1957, keeping in routine observation at every 15 or 30 min. The route of the navigation is shown in Fig. 1. The southernmost latitude reached is 69°15' in geomagnetic latitude in the Bay of Lützow-Holm.

The results obtained from the above sounding of the magnetic dependence of f_0F2 are represented in Figs. 2 and 3, corresponding to their noon and midnight values, respectively, taking the geomagnetic latitude as the abscissa. Here, the full line curve means the outward way and the broken the homeward way. It must be noticed that the data were derived from the observations carried out continuously and almost in the same conditions on the whole coverage of latitudes. These curves show the well-known characteristics with dips around the equator and the maxima on both sides of it. But, as they include regular and irregular variations and also longitudinal effects with themselves, it is not yet possible to find precisely the normalized shape of the characteristics free from the above variations

and effects. until the necessary hourly values throughout the world are made available.

Excerpt

PANT, B. D., R. R. Bajpai, and B. K. Verma. Ionosphere at Allahabad. Proc. Nat. Acad. Sci. India 6, 1961-174 (1936).

Observations for Nov. and Dec., 1935, show that 75-m. waves are usually reflected from the F-region. Sporadic E-reflections have, however, been observed on several nights. The noon ionisation of the E-region has been measured during the winter solistice period and found to be about 2×10^5 electrons per c.c. Both the group retardation as well as the stratification splitting has been observed, the former rather rarely. Long retardation echoes show the possibility of existence of ionised regions above the F-region. Complex echoes consisting of several peaks rapidly fading in and out have been seen several times. There seems to be no connection between the magnetic disturbances and the complex echoes. Observations for the reflection coefficient have been taken for the two rays, and values of the reflection coefficient greater than unity have been observed. The results find a satisfactory explanation on the hypothesis of an undulatory structure of the ionosphere together with the possibility of echo reception from directions other than vertical. Measurements of the reflection coefficient late in the night show that both the rays are absorbed in the reflecting region, a view contrary to those held by English workers. The desirability of taking more observations by several stations in collaboration is pointed out.
PA

PARKER, E. N. On the geomagnetic storm effect. J. Geophys. Res. 61, 625-637 (1956).

The high electrical conductivity of the region surrounding Earth, inferred from the observations of atmospheric whistlers and the zodiacal light, requires abandoning the customary models for producing a geomagnetic storm field with impressed current system. It becomes necessary to adopt a purely hydromagnetic approach wherein one focuses his attention only on the magnetic lines of force of the geomagnetic field and their displacement with the conducting gas surrounding Earth. From the hydromagnetic point of view, a decrease of the horizontal component is brought about by lifting the lines of force in the region above the observer. It is suggested that heating in the upper atmosphere may produce the necessary lifting; this model, along with another, is developed quantitatively to show that lifting the lines of force a distance of only 5 km will produce a decrease in the horizontal component of 0.2 percent at the equator.
A

PENNDORF, R. Classification of spread-F ionograms. J. Atmos. Terrest. Phys. 24, 771-778 (1962).

Scaling of original ionograms obtained in the polar regions has lead to a classification scheme for spread-F ionograms. Defined are three types of frequency spreading (spreadish-F, furcated-F and spurred-F) and one type of range spreading. Each type is subdivided into species. An example is given for the occurrence of each type on a magnetically quiet day at six polar stations. It is found that spreadish-F predominates and is found more often during the daylight hours than at night. The second most frequent type is range spreading which shows up during the night hours.
A

PENNSYLVANIA STATE COLLEGE. Proc. Conference on Ionospheric Physics, State College, Pa., 24-27 July, 1950.

PHADKE, K. R. Atmospheric noise interference to broadcasting in the 5 Mc band at Poona. J. Inst. Telecom. Engrs., New Delhi, 1, 136-146 (Sept. 1955).

Reports measurement of atmospheric noise interfence to broadcasting in the 5 Mc/s band at Poona, during the hours 18.00 to 23.00 (I. S. T.) by the method described by Aiya. The results are utilized to compute the data on noise necessary for broadcast services. These data are compared with the estimates of CRPL, Washington, and the measurements carried out on behalf of the Radio Research Board, London, at places in or near India. The discrepancies are explained and it is shown that both give lower values of noise. Noise levels are estimated from lightning discharge data and compared with measured values. There is close agreement between the estimates and the measured values. In all these comparisons, it is shown that such of the differences, as arise between the 3 Mc/s measurements reported elsewhere and the 5 Mc/s measurements, arise entirely from the differences in the propagation characteristics at the two frequencies.
EEA

PHILLIPS, G. J., and M. Spencer. The effects of anisometric amplitude patterns in the measurement of ionospheric drifts. Proc. Phys. Soc. B 68, 481-492 (1955).

In certain observations of a downcoming radio wave, made for the purpose of measuring horizontal drifts of ionospheric irregularities, time shifts between fading curves obtained at three spaced receiving points are used to calculate the velocity and direction of drift of the amplitude pattern over the ground. Two simplifying assumptions about the pattern are frequently made, namely (i) the detail remains constant as it moves, and (ii) it is statistically isometric, i.e. the separation of two points for which the amplitudes have a given fixed correlation is independent of direction.

The errors that arise if assumption (i) is wrong have been considered in a published paper. But a more general analysis, not relying on either assumption may be applied to the three fading curves, and the result expressed (either analytically or graphically) as the error of a calculation which makes the two assumptions. One important result is that if assumption (ii) is not valid the error in direction of drift may be quite serious. Thus, in an application to amplitude patterns produced by vertical reflection at 2.4 Mc/s (principally from the E layer), errors in individual results averaged 15°. Because the structure of the pattern varied from sample to sample, the error was not, in this case, systematic. But, in some applications, a preferred direction of the pattern structure could, if ignored, lead to wrong conclusions about preferred directions of drift.
A

PHILLIPS, W. E. Atmospheric super-refraction and the anomalous propagation of radio waves off the coast of Natal. S. African J. Sci. 48, 163-165 (1951).

Experimental evidence indicates that very short radio waves are propagated close to the surface of the earth over distances greatly in excess of the optical distances under favourable meteorological conditions. There is further evidence that energy thus propagated is in the nature of a ground wave confined to a "radio duct," and that the Kennelly-Heaviside layer plays no part in such propagation. The dependence of duct formation on the phenomenon of atmospheric super-refraction is well known and observations taken off the coast of Natal are given.
EEA

PIDDINGTON, J. H. Ionospheric drifts and E region irregularities. Planetary and Space Science 11, 639-653 (1963).

Physical interpretation of the components of electrodynamic drift of ionization in a lightly ionized gas. Only one component, representing the flux of "neutral ionization" appears capable of leading to the formation of irregularities in the electron density. A satisfactory theory of equatorial sporadic E, Es, must depend directly on the upward drift of ionization associated with the S_q dynamo. Two possible effects are discussed: an upward positive gradient of neutral atoms (caused by air turbulence) and an irregular distribution of negative heavy ions. In each case, strong convergence of electrons may result. A theory of auroral-zone sporadic E is briefly restated. It depends on the DS dynamo which includes large-scale shear motions in the magnetosphere, driven by the solar wind. These shear motions give rise to divergent electric fields in the ionosphere which cause convergence of neutral ionization in the E-region. These in turn react on the magnetosphere to cause ion precipitation, which adds a further contribution to sporadic E. Data for temperate-zone sporadic E strongly favor local winds. The theory of turbulence suggests that the largest wind cells should provide the highest wind speeds, and thus, the largest dynamo fields and drift velocities. Such large cells would tend to be free of shear throughout the E-region. They may cause convergence of ionization at various levels according to wind direction. A possible connection between E_s and thunderstorms may be explained in terms of winds extending into the E-region.
Source unknown.

PIGGOTT, W. R. On the variation of ionospheric absorption at different stations. J. Atmos. Terrest. Phys. 7, 244-246 (1955).

The possibility that the day-to-day changes in absorption at Slough, Swansea, and Freiburg are identical is examined statistically. After allowing for known sources of error, it is considered that the residual differences in summer months are too small to be significant, but that it is probable that real differences occur in winter. In both cases the minimum probable correlation for the Swansea-Slough comparison is very high - about 0.92.
A

PIGGOTT, W. R. The measurement of normal E-layer critical frequencies at night. J. Atmos. Terrest. Phys. 7, 341-342 (1955).

Although the characteristics of the normal E-layer during the day have been studied intensively, practically no reliable measurements of its critical frequency at night have been obtained. Such measurements are needed both for theoretical purposes and to provide a sound basis for studies of the propagation of medium waves at night.

Identifying the normal E-layer critical frequency at night is, however, very difficult, because the typical group retardation observed during the day becomes small when the critical frequency is comparable with the gyro-frequency and vanishes at lower frequencies. Thus at night the h'f patterns for normal and sporadic E reflections are indistinguishable.

The difficulty can be overcome by measuring the variation of absorption with frequency and time during the night, the absorption band associated with the critical frequency remaining very obvious even when no group retardation can be detected (e.g., for $\Delta P' < 2$ km).

The shapes of the absorption-frequency patterns, when plotted in the form $(-\log/\rho)$ against log (frequency), are very similar during any month, changing slightly with sunspot cycle and perhaps also with season. Using these shapes, one can deduce the critical frequency with good accuracy, even when echoes on frequencies below the absorption band cannot be measured or are not observed. It is, however, essential that the measurements should be made at closely spaced frequencies in order to define the shape of the absorption band.

The alternative procedure of observing the changes of absorption with time on a fixed frequency is not so satisfactory. The observed absorption contains two terms: the non-deviative loss which decreases steadily with time, and a deviative loss which first increases and then decreases with time. In addition, there are the disturbing effects of slow period fading to be eliminated. Thus the interpretation is difficult, especially when the critical frequency falls below about 0.8 Mc/s, since it then varies very slowly with time.

The results of some typical measurements are shown in Fig. 1. Near sunset, measurements could be made on frequencies above about 1 Mc/s, thus enabling the shape of the absorption band and the critical frequency of the E-layer to be determined with considerable accuracy. The deduced critical frequency could also be confirmed by observing the group retardation on a normal h'f record. Later, echoes could be detected occasionally below the absorption band with amplitudes roughly consistent with those to be expected, but the signal-to-noise ratio was inadequate for accurate measurement. The curves shown were obtained at Slough, using a sender with a peak output power of about 0.5 kW and a standard D.S.I.R. absorption measuring receiver having a large linear dynamic range (Piggott, 1955).

Aerials originally designed to work between 1.5 Mc/s and 3.0 Mc/s were employed. Intense medium-wave interference from broadcasting stations limited the accuracy. It was, however, clear that the experiment would be very easy, given about ten times as much power from the sender. It is perhaps worth pointing out that while it is very advantageous to increase the size of the sending aerials, signal-to-noise ratio is most important when designing the receiving aerials. Thus the latter need only be fairly short, but should be carefully balanced to reject vertically polarized medium-wave interference.

When the main trend of the critical frequency variation had been obtained, it was found possible to identify the absorption band on a few of the routine h'f patterns obtained at night at Slough. Usually this was difficult owing to the presence of E_s reflections and occasional fades due to layer irregularities. An interesting feature of the results was that the critical frequency was remarkably consistent on different occasions at corresponding times after sunset, differences greater than the experimental error of measurement being very unusual. The variation with time fitted a recombination law in which the recombination coefficient was about 1.10^{-8} for values of critical frequency above about 0.7 Mc/s, the lowest on which measurements could usually be obtained with the inefficient system available. It was also found that the weaker forms of sporadic E reflections often varied remarkably smoothly with time after sunset, the average difference between the critical frequencies of the E_s- and normal E-layers decreasing very slowly with time. The resultant variation of E_s critical frequency imitates a recombination law with a very small recombination coefficient.

Thus, useful information about the characteristics of normal E-layer at night can be obtained using comparatively cheap and simple equipment, and it is probable that absorption changes with frequency observed with high-power equipment would be very enlightening.
Excerpt

PIGGOTT, W. R. The calculation of the median sky wave field strength in tropical regions. Radio Res. Special Rept. 27, Dept. of Scientific and Industrial Research, London (1959).

A brief summary of the characteristics peculiar to low altitude propagation is given and the principles of the prediction system described. This is based on and extends the existing methods but uses revised values of the basic parameters and is modified to take advantage of recent work. The prediction equations are presented in nomogram form and enable the median field strength to be computed for ranges of 0 to 4000 km to any epoch in the solar cycle. The range can be extended as required. The parameters adopted are summarized in an appendix. Curves are given showing where aerial polarization may be important in determining the field.
A

PIGGOTT, W. R. A daily index of F2 layer disturbance during the IGY. IN: Beynon, W. J. G., ed., Some Ionospheric Results Obtained During the IGY, Proc. Symposium URSI/AGI Committee, Brussels, Sept. 1959, 116-123 (Elsevier Publishing Co., New York, 1960).

A daily index of F layer disturbance has been constructed for the I.G.Y. For this purpose the world has been divided into five zones: equatorial, N.E., N.W., S.E. and S.W. The degree of disturbance in each zone is estimated using a range of criteria and the days of each month arranged in order of increasing disturbance. The order is checked by the f-plots for each day from selected stations and an over-all index allocated. Most entries are based on observation at 15 well-spaced stations but in cases of doubt a further 18 have been used. One whole month and selected periods of others have been checked using every station whose data had reached the World Data Centre at Slough.
Excerpt

PIGGOTT, W. R. Discrepancies in the ionospheric absorption deduced from the first order and multiple order reflections. IN: Beynon, W. J. G., ed., Some Ionospheric Results Obtained During the IGY, Proc. Symposium URSI/AGI Committee Brussels, Sept. 1959, 263-269 (Elsevier Publishing Company, New York, 1960).

The well-known difficulties due to the discrepancies between the ionospheric absorption deduced using the first order reflection and that found using higher orders are discussed. These discrepancies are due to a systematic difference in the attenuation of the first order which is, on the average, 3 db weaker in the day than would be expected from absorption theory. The anomaly appears to be associated with the changes in fading between night and day. Data analysed by the standard I.G.Y. method using the first order echo only will, therefore, show a systematic difference with data obtained earlier using other methods. The danger of relying on the ratio of the amplitudes of the first and second order echoes is stressed.
A

PITTEWAY, M. L. V., and R. Cohen. A waveguide interpretation of 'temperate-latitude' spread F on equatorial ionograms. J. Geophys. Res. 66, 3141-3156 (1961).

A waveguide model is presented for propagation of radio waves along elongated irregularities aligned parallel to the earth's magnetic field in the

equatorial ionosphere. This theory is applied to analyze the frequency spread ionograms often observed during the equatorial night, particular attention being devoted to the detailed striations of the spread; similar spread-F striations on arctic ionograms are explained by a corresponding waveguide theory. The waveguide theory is consistent with direction-finding evidence that the category of spread F considered in this paper is caused by back-scatter in the north-south plane from irregularities that do not support north-south forward scatter at 50 Mc/s. These echoes are in contrast to those arriving in the east-west plane from the 'equatorial spread F' irregularities considered elsewhere, which do support north-south forward scatter at 50 Mc/s. This paper is concerned with propagation in an irregular ionosphere, but not with the formation of the irregularities.
A

PRAMANIK, S. K., and P. S. Hariharan. Diurnal magnetic variations near the magnetic equator. Indian J. Met. Geophys. 4, 353-385 (1953).

The diurnal variation of H at Huancayo is found to be considerably larger than that expected in such regions. McNish (1937) explained the large variation as follows. According to the dynamo theory the main electrometric forces are induced in middle and higher latitudes, which drive the current eastwards in low latitudes, where, if the geographic and geomagnetic equators coincide, it is opposed by the electromotive forces induced there, but if the two equators are apart, then in the region between these two, the electromotive forces induced there help the current flow, resulting in its enhancement.
Excerpt

PRAMANIK, S. K., and S. Yegna Narayanan. Diurnal magnetic variation in equatorial regions. Indian J. Met. Geophys. 3, 212-216 (1962).

The large diurnal variation in H at Kodaikanal has remained unnoticed and it was the still larger diurnal variation at Huancayo which when examined by McNish led to the discovery that the magnetic diurnal variations there were markedly different from those expected for such a region. McNish's explanation implied that this large diurnal variation at Huancayo was due to its position between the geomagnetic and magnetic equators, and he pointed out that at places where the magnetic equator was situated far from the geographic equator an increase of the diurnal variation would occur.
Excerpt

PRICE, A. T., and G. A. Wilkins. The daily magnetic variations in equatorial regions. J. Geophys. Res. 56, 259-263 (1951).

A new analysis of the Sq-field for the Polar Year 1932-33 indicates that the maximum daily variation of H in equatorial regions is to be found between the magnetic and dipole equators in South America and Africa, but occurs to the south of both these equators in the Far East. It also appears that the line of maximum variation varies in position with the season, its movement being in the direction opposite to that of the sun.
A

PROBST, S. E., and G. E. Krause. IBM 704 program to determine MUF and LUF for HF radio propagation. Project No. 625, U. S. Army Signal Radio Propagation Agency, Ft. Monmouth, N.J. (Oct. 1959).

This reports presents a detailed explanation and analyses of an IBM 704 program to determine the Maximum Usable Frequency (MUF) and the Lowest Useful High Frequency (LUF) for HF radio propagation. It is intended mainly to guide programmers toward a comprehensive understanding of the techniques developed, so that it may be used by other organizations. Necessary details are included so that a program, Appendix A, written for a specific propagation problem may be tailored to fit any general MUF-LUF propagation problem.
A

PURSLOW, B. W. Ionospheric drift in the F2 region near the magnetic equator. Nature 181, 35-36 (1958).

Measurements of horizontal drifts in the F2-region at Singapore by the spaced-receiver method indicate that these are predominantly east-west with a 24 hour period, changing from maximum easterly (~ 90 m/sec) at night to westerly (~ 30 m/sec) by day. The north-south component is generally much smaller. These results are in phase opposition to those found for higher latitudes, and may be interpreted as evidence for Martyn's theory of electromagnetic coupling between the E-region (where the dynamo currents flow) and the F-region along the magnetic lines of force.
PA

RAJAM, C. V. Wave-forms of atmospherics at Madras. Nature 138, 1064 (1936).

Describes typical atmospheric wave forms and sound. About 90 percent of observed atmospherics have damped oscillations of 800 to 40,000 cps. These "rippled" atmospherics produce jarring clicks. Non-rippled atmospherics (non-oscillating pulses) produce non-jarring clicks. Frying sounds are associated with quasi-periodic oscillations.
M

RAKSHIT, H. Estimation of height of Heaviside layers in Bengal. Phil. Mag. 12, 897-907 (1931).

No attempt has been made to estimate height in subtropical regions, like that of India; to know approximate height of this layer under as widely varying geographical, geophysical, and meteorological conditions as possible. Measurements in subtropical climate of Bengal were taken.
EI

RAKSHIT, H. Measurement of ionospheric heights at Calcutta during the Solar Year 1932-1933. Phil Mag. 18, 675-696 (1934).

Measurements were made at Calcutta of ionospheric heights, using the group-retardation method and a wave-length of 75 m. The results obtained during 1932-33 are here summarised and discussed. The results show that the height of both the E- and F-layers generally reaches a minimum value about mid-day. The height is a maximum about 20 or 30 min. before ground sunrise and then falls abruptly to the normal daytime value within about an hour after ground sunrise. On an average, the height of either layer is greater in winter than in summer and the noontime ionisation of either layer is greater in summer than in winter. Echoes from the F-layer are frequently found at night to be split up into a large number of components, due to the influence of the earth's magnetic field. Immediately after the appearance of such splitting the echoes are found to disappear completely. A possible explanation of this effect is given. The observations also indicate the existence of a steeper gradient of ionization density in the E-layer than in the F-layer. The gradient was found to diminish with increase of height.
A

RAMANA, K. V. V., and B. Ramachandra Rao. Investigation of ionospheric absorption on 5.65 Mc/s at Waltair. J. Atmos. Terrest. Phys. 22, 1-11 (1961).

This paper presents the results of ionospheric absorption measurements conducted at Waltair (Latitude 17.7° N, Longitude 83.3° E and Geomagnetic Latitude 7.4° N) during the International Geophysical Year and International Geophysical Co-operation periods on a frequency of 5.65 Mc/s.

The solar zenith distance variation of diurnal and seasonal data of absorption follows a law of the form

$$8.7 \left| \log_e \rho \right| = A'_1 \cdot (f)^{-2} \cdot \cos^n \chi \text{ dB}$$

only as an approximation. The variation of the cos χ index has a significant negative correlation with Zürich relative sunspot number R.

The monthly mean diurnal variation as well as seasonal noon-time variation of absorption confirms, more precisely, to a law of the form

$$\left| \log_e \rho \right| = A' + B \cdot F(f_0E/f) \cos \chi \text{ nepers}$$

where A' is a constant expected to refer to the non-deviative absorption in lower D-region. A' is found to vary linearly with R.

A method is suggested to estimate the relative amounts of D- and E-region absorption at noon from the cos χ index data. The absorption $|\log_e \rho|$ and A' are found to vary inversely as the square of the operating frequency.

A

RAMANA, K. V. V., and B. Ramachandra Rao. Lunar daily variation of horizontal drifts in the ionosphere at Waltair. J. Atmos. Terrest. Phys. 24, 220-221 (1962).

Data obtained at Waltair (geomagnetic latitude 7.4° N) during 1956-1959 were used to study the lunar tidal effect on E- and F-region drifts. A table of 12-hourly harmonics of lunar daily horizontal drift is given and shows a large seasonal amplitude variation of both NS and EW components for the E-region, and a smaller variation for the F-region. The seasonal variations of the 12-hourly drift vectors are incompatible with the tidal wind theory, probably due to highly anisotropic irregularities in the ionosphere at Waltair. There is also a discrepancy between the direction of the observed drifts at a given time and the direction that would be expected from the lunar barometric pressure oscillations on the ground.

PA

RAMANATHAN, K. R., R. V. Bhonsle, K. M. Kotadia, and R. G. Rastogi. The great solar flare of 23 Feb. 1956 and associated ionospheric effects at Ahmedabad. Proc. Indian Acad. Sci. 43, 306-308 (1956).

Display record of cosmic noise on 25 Mc/s showing about 6.5-db absorption during solar flare of 23 Feb 1956. Tabulate time of fade-out for half-dozen h-f communication circuits and mention vertical-incidence pulse absorption.
M

RAMANATHAN, K. R., R. V. Bhonsle, and S. S. Degaonkar. Effect of electron-ion collisions in the F region of the ionosphere on the absorption of cosmic radio noise at 25 Mc/s at Ahmedabad. Changes in absorption associated with magnetic storms. J. Geophys. Res. 66, 2763-2777 (Sept. 1961).

Measurements of cosmic radio noise at 25 Mc/s, made at the Physical Research Laboratory, Ahmedabad, since March 1957, show much larger values of absorption than those observed by Shain and Mitra in Australia. This fact, together with the empirically known dependence of the absorption on the critical frequency of the F region, and the effect of magnetic storms on the absorption found from the Ahmedabad observations led the authors to examine the different possible parameters that may affect cosmic-noise absorption. It was found that electron-ion collisions in the F region both below and above the level of maximum electron density contribute in a substantial way to the absorption of cosmic radio noise. The values of hourly absorption due to collisions of electrons with neutral particles and with ions were calculated for a period of 6 days in August-September 1957, when there were three magnetic storms. The results obtained show a depletion of electrons above F maximum on the day following the commencement of the magnetic storm and a refilling on later days. The results are discussed in relation to findings from satellite observations about particle fluxes in the Van Allen belts during magnetic storms.
A

RANGARAJAN, S. The sporadic-E layer at Kodaikanal. J. Geophys. Res. 59, 239-246 (1954).

An examination of the ionospheric records at Kodaikanal, which is located almost on the geomagnetic equator, reveals that the sporadic-E layer here has some regular features not observed at other latitudes. It

occurs in nearly 93% of the half-hourly records during the daytime. Two main types of Es are observed; namely, (1) the patchy type with a well-marked di... nal variation and (2) which occurs mostly during afternoons. It is found that neither meteoric activity nor thunderstorm activity has any appreciable influence on the formation of either of the two types of Es. No correlation is observed between Es and the geomagnetic field.
N

RANGASWAMY, S., and S. C. Krishnan. Ionospheric observations at Madras during IGY and IGC. J. Inst. Telecom. Engrs. 8, 239-245 (1962).

Diurnal variation of critical frequency and height of maximum ionization noted by Ionospheric Station of All India Radio at Madras is shown to follow trend recorded in other "equatorial" stations; occurrence of spread echoes follows "equatorial" pattern and has inverse relationship with geomagnetic activity; sporadic E is common during daytime but values of fEs are significantly lower than those observed at equatorial stations like Trivandrum, Tiruchirapalli and Huancayo.
EI

RANGASWAMY, S. Lunar control of noon critical frequencies of the F2-region. J. Atmos. Terrest. Phys. 25, 545-549 (1963).

This note deals with the variation of noon critical frequencies with the phase of moon at three "equatorial" stations. The mean variation for a lunation was determined separately for the three seasons, namely the June and December solstices and the equinoxes, for Madras (magnetic lat. 5.3°N). The phase of the lunar variation in the June solstice differed from that in the December solstice by nearly 5 hr (or 150°). The amplitude in June solstice was about half that in December solstice. The phase of the equinox variation was nearly the same as in northern summer. The amplitude of the mean annual variation in 1957 and 1958 (sunspot maximum) was found to be nearly half of the amplitude in 1954 (sunspot minimum) while the phase for the two epochs is nearly constant. The reduction in amplitude in 1957-58 is due to large phase difference of the variation in the different seasons.

For comparison, data from Kodaikanal (magnetic lat. 1.8° N) and Huancayo (magnetic lat. 0°) have been analyzed. The seasonal change in phase of the lunar semi-diurnal variation was found to be about 90° for Huancayo between the solstices and about 150° for Kodaikanal. The value

of the phase for Huancayo in 1957-59 when compared with that in 1941-44 shows that the change in phase is twice in 1957-59 that in 1941-44 for the two solstices. It is tentatively concluded that the seasonal change in phase of the lunar variation in critical frequency varies with latitude and sunspot activity.

The above results can be summarized as follows:

(i) The phase of the semi-diurnal lunar variation at low latitude stations changes from the June solstice to December solstice. This difference in phase is sometimes as large as 150°. The lunar variation referred to is with reference to solar control hour of noon. The large phase difference of the lunar variation between the seasons has the effect of decreasing the amplitude of the mean annual variation.

(ii) The seasonal difference in phase varies with latitude.

(iii) There seems to be a relation between the sunspot activity and seasonal change in phase. Further work is in progress to determine the change in seasonal characteristic of the phase with latitude and sunspot epoch.

Excerpt

RANGASWAMY, S., and K. B. Kapasi. A study of equatorial spread-F. J. Atmos. Terrest. Phys. 25, 721-731 (1963).

Data from seven stations ranging in magnetic dip from 0° to 44° N have been analyzed to study night time and seasonal variations of spread-F through nearly half a solar cycle. It is observed that the inhibition of spread-F due to geomagnetic activity is maximum in the equinoxes. In the belt of magnetic dip 0° to 10° a second peak in the occurrence of spread-F is observed during the night hours.

At a typical equatorial station, the occurrence of spread-F is observed to increase with sunspot number. A similar variation is observed in h'F also. At stations with magnetic dip $\geqslant 18°$, the occurrence of spread-F increases with sunspot number in equinoxes but decreases with sunspot number in summer. A significant lunar variation is observed in the occurrence of equatorial spread-F which suggests that electrodynamic drift plays a major role in the occurrence of equatorial spread-F.

A

RAO, A. Sanyasi, and B. Ramachandra Rao. Horizontal drifts in the F2-region at Waltair. J. Atmos. Terrest. Phys. 25, 249-262 (1963).

Results of analysis of drift measurements made at Waltair for F2-region over a period of 2 years are presented. The main features of the diurnal and seasonal variation of drifts in the F2-region at this low latitude station are given in detail. These are compared with earlier results from high, middle and low latitude stations as well as results obtained at this same station by previous workers.
PA

RAO, A. Sanyasi, and B. Ramachandra Rao. Horizontal drifts in the E-region at Waltair. J. Atmos. Terrest. Phys. 26, 399-415 (1964).

Results obtained at Waltair on the measurement of ionospheric drifts for the E-region over a period of 2 years by spaced receiver technique are presented in this paper. The main features of the diurnal and seasonal variation of drifts in the E-region at this low latitude station are given in detail. These are compared with earlier results from other latitude stations as well as those obtained at this same station by previous investigators.
A

RAO, B. C. Narasinga. Studies of equatorial F region. Scientific Rept. 9, National Physical Laboratory, New Delhi, (1 Dec. 1962).

The characteristic features of the equatorial F-region are studied using the published data. The study reveals some important differences in the equatorial anomaly in the Asian, African, and American zones. The location of the F-region equator is examined, and the results indicate that the F-region equator does not correspond exactly to the magnetic-dip equator, but is shifted slightly toward north in the Asian and American zones, and slightly toward south in the African zone. The diurnal variation of F-region critical frequency showed peculiar post-sunset rise in the transition region. This is found to depend on the solar activity and the characteristic post-sunset rise in the height of the equatorial F-region.
STAR

RAO, B. C. Narasinga. Some characteristic features of the equatorial ionosphere and the location of the F-region equator. J. Geophys. Res. 68, 2541-2549 (1963).

The characteristic features of the equatorial F region are studied using the published ionospheric data. The study reveals some important differences in the Asian, African, and American zones. In the diurnal variation of f_oF_2 there are two peaks, one in the forenoon and the other in the afternoon, in the Asian zone, whereas the afternoon peak is absent in the American zone during sunspot maximum. The width of the equatorial trough is smaller in the American than in the Asian zone. The location of the F-region equator is examined; the results indicate that the F-region does not correspond exactly to the magnetic dip equator but is shifted slightly toward the north in the Asian and American zones and slightly toward the south in the African zone.
A

RAO, B. C. Narasinga. The postsunset rise of f_oF_2 in the transition region and its dependence on the postsunset rise of h'F in the equatorial region. J. Geophys. Res. 68, 2551-2557 (1963).

In the transition region lying between the equatorial anomaly region and the middle latitudes a characteristic postsunset rise in f_oF_2 is observed during years of high sunspot activity. This phenomenon is found to depend on the evening height rise in the equatorial region. The analysis presented in this paper substantiates the view that the ionization lifted over the equatorial region is transported along the magnetic lines of force to the transition region.
A

RAO, B. Ramachandra, and E. Bhagiratha Rao. A continuous radio wave method of studying travelling disturbances in the ionosphere. J. Sci. Indus. Res. 13A, 462-466 (1954).

Different methods of determining ionospheric drift are reviewed, and the new method, which involves measurement of the time difference between passage of peculiar peaks on continuous ionospheric records, between one station and another nearby station with nearly the same frequency, described in detailed and numerical examples cited and records presented by way of illustration. The stations cited are Calcutta, and Dacca, in 41 m band. Data for May and June 1953 show movements ranging from

7 to 21 km/min, over a distance of 120 km. Reasons for assuming the drift to lie in the F rather than the E layer are given. Movements are usually toward the south (N-wind) but one case shows opposite drift.
N

RAO, B. Ramachandra, and B. C. Narasinga Rao. A continuous wave radio method of studying the variation of critical frequency of the E-region of the ionosphere. Proc. Mixed Commission on the Ionosphere, Brussels, 16-18 Aug. 1954, 103-107 (1954).

A new type of fading observed at Waltair during morning hours on signal-strength records of medium waves from Madras (640 km) is interpreted as due to variations of the equivalent paths in the ionosphere of singly and doubly reflected waves as the critical frequency varies. The period of fading depends on the actual rate of critical frequency variation, and almost minute-to-minute variations of foE can be determined over say half an hour to an accuracy greater than 0.01 Mc/s, assuming there is no layer lifting in the ionosphere.
PA

RAO, B. Ramachandra, M. Srirama Rao, and D. S. Murthy. A note on ionospheric wind measurements at Waltair (India). Proc. Mixed Commission on the Ionosphere, Brussels, 16-18 Aug. 1954, 158-161 (1954).

Fading patterns of pulse signals received at three stations forming a right-angled triangle (N-S and E-W spacings ~ 110 m) have been used to measure daytime "wind" velocities and directions in the E-region (using 2.5 Mc/s) and F-region (using 5.9 Mc/s). Results indicate velocities of 40-80 m/sec (E-region) and 80-120 m/sec (F-region). In winter the direction is predominantly towards the S.W. both for the E- and F-regions; in summer towards the E. (E-region) and the N. W. (F-region).
PA

RAO, B. Ramachandra, M. Srirama Rao and D. S. Murthy. Investigation of winds in the ionosphere by spaced receiver method. J. Sci. Indus. Res. 15A, 75-91 (1956).

Details of equipment and results of soundings presented in text and illustrations (recorder records), polar diagrams showing seasonal variation of wind movements in the E and F region in winter from NE and summer (W in E layer, indefinite in F); wiring diagrams, etc. based on spaced receiver observations (MITRA, 1949), made at the Ionospheric Laboratory at Andhra Univ., Waltair, India, in 1954 using 3 receiving antennas and one pulse sender operating in the 2-6 Mc/sec range with a pulse width of 200 microseconds.
N

RAO, B. Ramachandra, and K. V. V. Ramana. Diurnal variation of ionospheric absorption on 5.65 Mc/s at Waltair during the IGY. J. Sci. Indus. Res. 17A, 56-58 (1958).

Using the reflected-pulse technique, the dependence of absorption at Waltair (17°N, 83°E) on the cosine of the solar zenith angle has been determined. A mean value of 1.25 was found for the exponent of the cosine term, and the average ratio of summer to winter noontime absorption is 2.2.
PA

RAO, B. Ramachandra, and E. Bhagiratha Rao. Effect of enhanced solar activity on the F_2 region drifts at Waltair. J. Sci. Indus. Res. 17A, 59-62 (1958).

Evidence of marked anomalies in the diurnal variation of F2 region drifts observed at 17°N, 83°E are reported for days on which prominent solar flares occurred. These results can be explained by invoking a reversal of the S field in the dynamo region at this latitude on solar flare days.
PA

RAO, B. Ramachandra, and E. Bhagiratha Rao. Horizontal ionospheric drifts in the F2-region at equatorial latitudes. Nature 181, 1612-1613 (1958).

Measurements using the spaced-receiver method at Waltair (17°43'N) have shown that both the N—S and E—W components have a predominant 24 hr period, with a net direction which changes in a clockwise sense. The direction of drift is opposite to that observed at higher latitudes, in agreement with Martyn's theory.
PA

RAO, B. Ramachandra, and D. S. Murty. A new continuous wave radio method for the study of ionospheric drifts. J. Sci. Indus. Res. 17A, Suppl., 63-67 (1958).

Measure ionospheric drifts by recording signals from distant transmitter on 3 receiving antennas. Analyze time displacements of fading as in Mitra method. Compare results with standard spaced-receiver pulse method, say very consistent. State can measure drifts in different parts of ionosphere from central observing station.
M

RAO, B. Ramachandra, E. Bhagiratha Rao, and Y. V. Ramana Murty. Effect of magnetic activity on drifts of the F2 region. Nature 183, 667-668 (1959).

Contrary to the results obtained at higher latitudes, it is found that at Waltair (9°N), the F2-region drift speeds decrease linearily with increasing K-index.
PA

RAO, B. Ramachandra, and E. Bhagiratha Rao. Study of horizontal drifts in the F1- and F2-regions of the ionosphere at Waltair (17°43'N, 83°18'E, mag. lat. 9°30'N). J. Atmos. Terrest. Phys. 14, 94-106 (1959).

Results of the analysis of drift measurements made at Waltair for the F1- and F2-regions over a period of 2 years are presented in this paper. The main features of the diurnal and seasonal variation of drifts in F2-region are given in detail. The general pattern of drift movements for this low latitude station is found to be in phase opposition to those observed at high latitudes, thus confirming F2-region drift theory given by Martyn (1955).
A

RAO, B. Ramachandra, and R. Raghava Rao. A new type of ionospheric drift recorder. J. Atmos. Terrest. Phys. 21, 208-210 (1961).

The spaced receiver method developed by Mitra (1949) has been used extensively by several investigators for measurement of horizontal drifts in the ionosphere as it has the main advantage that it can be used practically all the time. The method is, however, laborious particularly as it involves photographic recording of the fading signals and analysis of records. The need has been long felt for the development of an instrument in which the time displacements are directly recorded. The Phillips recorder (1955), developed with this end in view, has the major advantage over signal recording methods that the time delay is recorded with its proper sign as a deflection on a pen recorder. Although the Philips recorder is decidedly an improvement over the usual method, it has the drawback that the recorder does not work reliably at all times and further considerable calculation is involved in order to obtain average time displacements. In this communication the authors present a brief description of a new type of drift recorder developed by them which gives the average time difference between any two fading records from spaced aerials.

While all the previous methods for ionospheric drift measurements are concerned with measuring time displacements by comparing the actual fading patterns and recording time difference between maxima or minima,

the present method is based on the principle of introducing a time delay into one of the pair of time varying fading signals such that there is no net average time difference between them. In other words the delay introduced will be such as to compensate the average time difference originally existing between the two signals. This variable time delay is introduced by using a magnetic tape recorder with a continuously driven endless tape and a manually variable record-reproduce head separation. The block diagram of the entire experimental set-up is shown in Fig. 1

Signals from aerials A_1, A_2 and A_3 situated at the three corners of a right-angled triangle are fed into three identical BC 348 receivers converted for pulse operation. A one-pole two-way switch S_1 permits the comparison of fading of signals from either aerials A_1—A_2 or A_2—A_3. The amplified and detected signals from either of these pairs of aerials is fed into gated integrators I and II to isolate one of the required signals from the ionosphere and integrate the pulses (which have a repetition frequency of 50 c/s) to give a smoothed d. c. output signal whose variation is a true replica of the original signal. The output from the gated integrator I is fed into a frequency modulator, which generates square waves the frequency of which vary from 4·2 to 9·8 kc/s as the input signal varies from minimum to maximum, the range of input signal variation being 24 V. The frequency modulated signals from this unit are fed into a magnetic recording head which is in contact with a magnetic tape driven at a speed of 7·5 in/sec. The signals recorded on the magnetic tape are received by a reproducing head and the distance between it and the recording head can be varied continuously, so that a known time delay is introduced in the signal. It is found that the maximum separation required does not exceed 10 in., corresponding to a delay of about 1-1/2 sec. The signal from the reproducing head is fed into an amplifier and demodulator stage, the output of which is a true replica of the original signals but with a time delay. The outputs from the demodulator and the gated integrator II are adjusted to be equal and are fed into a double triode balanced cathode follower amplifier between the cathodes of which is placed an a. c. milliammeter. The deflection in the detector, due to the a. c. voltage between the cathodes, is a function of the time delay between the almost similar input signals. When the time delay between the signals is adjusted on the average to be zero, the deflection in the a. c. milliammeter will be a minimum. By manually varying the reproducing head position to give minimum output in the a. c. detector, and noting the distance between the record and reproduce heads and the speed of the tape, the time delay T is obtained. This minimum is observed only if the signal output of receiver 2 is delayed with respect to that of receiver 1. In cases in which the time delay is the other way, the receivers connected to the gated integrators are inter-changed by a double-pole double-throw switch S_2 so that the signal whose phase is ahead is fed into the tape delay system following the gated integrator 1.

The main advantage of this method is the simplicity in obtaining average time delay without having recourse to taking fading records. The accuracy of delay control setting for minimum in the detector is not high, but the overall accuracy can be improved by taking the average of several observations. The recorder has the limitation that it can record a minimum time delay of 0·70 sec. A detailed paper giving all the technical details will shortly be published elsewhere.
Excerpt

RAO, B. Ramachandra, and K. V. V. Ramana. Variation in height of anisotropy and random drift velocity of the irregularities in the ionosphere. Nature 190, 706-707 (1961).

Horizontal drifts of ionospheric irregularities, at heights between 100 and 400 km, were studied in South India by the spaced receiver method, using pulses at several radio frequencies. The elongation of the irregularities, and the rate of random change of the fading pattern, were found to be much greater at 270 to 290 km than at other heights.
PA

RAO, B. V. T., and M. K. Rao. Ionospheric absorption over Delhi. J. Inst. Telecom. Engrs. 4, 205-208 (1958).

An automatic method of measuring ionospheric absorption on vertical incidence pulsed transmissions has been developed. The equipment and some preliminary observations have been described earlier (see B.V.T. Rao 1958). Regular measurements by this recorder were commenced in June 1954 and are still in progress. Further measurements made till October 1957 are analyzed here. Absorption was measured on 5 Mc/s every day at midday and at different times on other occasions. The analysis of data reveals the following: (a) running average of the monthly midday absorption is well correlated with corresponding running average of sunspot numbers; (b) the diurnal variation factor n has been evaluated on some occasions and has been found to lie within the range 0.33-1.13 with more than 80% of values between 0.33 and 0.9; (c) in the evaluation of relaxation time, two maxima of absorption, one in the forenoon and the other in the afternoon, have been occasionally observed although there are a few clear instance of only one postnoon maximum; (d) attempt has been made to work out seasonal variation of midday absorption from the measurements. The results described are rather tentative as measured values of ionospheric absorption spread over a large number of years are required for arriving at definite conclusions.
EEA

RAO, C. S. Raghavendra. Solar tidal effects in the F_2-region of ionosphere over Delhi. Indian J. Phys. 31, 516-525 (1957).

Ionospheric data collected at Delhi over the period 1946-1955 have been analyzed for these effects. The method developed by Martyn and extended by Mitra has been utilized for the purpose. The magnitude and phase of the

drift velocities for the different seasons and the relative importance of the drift velocity are determined. While the seasonal velocities have been found to be of the order of 20, 18 and 33 km/hr for summer, winter and equinox months, the ratio of the seasonal to semi-diurnal velocity has been obtained to be of the order of 1.5. This agrees well with the result obtained by Martyn. The observed variations in N_m have been explained in terms of the phases of the drift velocities. The values of the attachment coefficient for the three seasons of the year have also been determined taking the tidal effects into consideration. These are found to agree fairly well with the recent results of Ratcliffe et al.
PA

RAO, C. S. R., and J. C. Bhargava. MUF factor and solar activity. Indian J. Phys. 34, 85-91 (1960).

Deals with the variation of $M(3000)F_2$ factor with sunspot activity. The ionospheric data for Delhi and Ahmedabad for the period 1950 to 1958 have been considered. The analysis indicates that a fairly good linear relationship exists between $M(3000)F_2$ and sunspot number for both the places. A preliminary study of the variation of Y_m and h_o with sunspot activity (Ahmedabad) has also been made.
PA

RAO, C. S. R., and T. N. Ranganathan. Ionosphere over Trivandrum--Part I. J. Inst. Telecom. Engrs. 6, 161-167 (1960).

This paper deals with the study of some of the characteristics of the F2 region of the ionosphere over Trivandrum, where an ionospheric station was established towards the end of 1956. The data obtained during 1957 have been utilized for studying the total electron content of the F2 region and the calculation of the recombination coefficient and the temperature of the F2 region. The total electron content in a vertical column of unit cross-section below the level of maximum ionization has been studied for different times of the day and for summer, equinox and winter seasons of the year. Analysis of the data indicates that the diurnal variation of the total electron content is smoother than that of the electron density. The 'bite-out' effect observed in the variation of electron density is completely removed when the variation of electron content is considered. The recombination coefficient has been calculated for different seasons from a consideration of the rate of variation of the total electron content at times equally spaced but on either side of the local noon. The values obtained are comparable with those found elsewhere. The temperature of the F2 region has been arrived at from a consideration of the scale height. Atomic oxygen has been assumed to be the main constituent in the F2 region. The temperature varies from about 800°K to 1800° K at different times of the day. The existence of such high temperature at the F2 region has been confirmed from recent rocket and satellite explorations.
A

RAO, C. S. R., and S. C. Bose. Electron distribution in ionosphere over Trivandrum. J. Inst. Telecom. Engrs. 7, 181-188 (1961).

Records taken at Trivandrum from Apr 1959 onwards with manual ionospheric equipment installed by Research Department of All India Radio; preliminary study of electron distribution in ionosphere is made by obtaining N(h) profiles from h'-f curves.
EI

RAO, C. S. R. Study of the geomagnetic anomaly during sunspot maximum. J. Atmos. Terrest. Phys. 24, 729-737 (1962).

The data on the critical frequency of the F2-layer and N(h) profiles obtained for a number of stations during the IGY have been utilized in this paper in a study of the geomagnetic anomaly in the F2-region. Data for the months of September 1957 and March 1958 have been considered as representative of the equinoxial months during a year of high sunspot activity.

Using the N(h) profile data, the subpeak electron content of the ionosphere has been obtained. Curves showing the latitudinal variation of maximum electron density ($N_m F2$) and of subpeak electron content (n_t) have been drawn and compared for all the even hours of the day. The following facts are observed:

Starting as a flat one before sunrise, the maximum electron density curve develops an equatorial maximum after sunrise. This maximum becomes strong at 1000 hours local time. At 1200 hours this maximum shifts to the middle latitudes (between 30° and 40°) leading to a shallow trough at the equator. The trough becomes more pronounced during later hours and is maintained up to midnight. From then onwards it gradually disappears, giving rise once again to the flat curve observed just before sunrise. The subpeak electron content curves show a similar trend. The daytime maximum of the curve is, however, between latitudes 15° and 20°.

Comparing the maximum electron density curves obtained above with those obtained during a year of sunspot minimum activity, the trends are seen to be similar. The equatorial trough, however, develops much earlier (3-4 hr) and also disappears much earlier during the sunspot minimum year.

Diurnal variation curves for both maximum electron density and subpeak electron content for the magnetic latitudes 0-60°N have been drawn at intervals of 10° and compared. The variations of subpeak electron content are smoother.

Martyn's theory of horizontal divergence of ionization from the magnetic equator accounts for the general features observed here. But the phase shift between the sunspot minimum and minimum years remains to be explained.
A

RAO, C. S. R., and M. Sain. Total electron content in F2 layer over Madras during 1959. J. Inst. Telecom. Engrs. 8, 179-185 (1962).

Some characteristics of F2 layer of ionosphere over Madras for period Feb 1959 to Jan 1960 studied; data for both quiet and disturbed days is

analyzed; diurnal variation of F2 layer critical frequency for different months; total electron content in vertical column of unit cross-section below level of maximum ionization is calculated, on assumption of parabolic distribution, for different times of day and for different seasons.
EI

RAO, C. S. R. Some pecularities in the diurnal variation of maximum ionization density of the F2 layer. Nature 198, 276-277 (1963).

Firstly, a curious reduction is noticed in the increase, between low and high sunspot activity, of the before-noon peak in foF2 for those stations which exhibit the midday "bite-out" effect. Secondly, the linear relationship between f_0F2 and the 12 months' running average sunspot number, R, does not seem to hold good for R greater than about 150.
PA

RAO, C. S. R. Sporadic-E and the equatorial electrojet. J. Atmos. Terrest. Phys. 26, 417-427 (1964).

An analysis of characteristics of sporadic-E at Indian and American equatorial stations has been made for quiet and disturbed days during the year 1958. The analysis reveals certain differences between the two chains of stations which indicate a possible difference in the width of the equatorial electrojet at the two zones. In both the annual and seasonal variations on quiet days, values of Es are always higher at Indian stations. Disturbed day value of fEs is lower than on quiet day. Latitudinal variation of the noon fEs on quiet and disturbed days has been drawn for both the zones and a difference in the two zones found to occur. In addition, it is observed from the superposed epoch method of analysis for disturbed days, fEs shows a drop compared to the quiet day values and the amount of drop is reduced as one goes away from the magnetic equator. Corresponding dips are found in the values of the horizontal component of the earth's magnetic field. The differences observed in the two zones, possibly due to the effect of the equatorial electrojet are pointed out. The percentage occurrence of Es also shows characteristic diurnal variation in all seasons at the two zones. The latitudinal variation of the percentage occurrence of Es shows considerable differences indicative of a possible difference in the width of the electrojet at the two areas.

The variation of noon fEs with sunspot activity for Indian stations shows that there is an increase in fEs with increase in sunspot number. The increase up to a sunspot number of about 100 is not much; but afterwards the rise if fairly rapid and linear up to a very high sunspot number. This is compared with the corresponding f_0F2 variations which show saturation effects after a sunspot number of about 120.
A

RAO, C. V. S., and S. N. Mitra. Spread F and geomagnetic activity. J. Geophys. Res. 67, 127-134 (1962).

Ionospheric observations on the occurrence of spread F at Trivandrum for the period March 1957 to February 1960 have been analysed to study the correlation between geomagnetic activity and spread F. An inverse linear relationship has been found to exist between the two parameters. On all quiet days, spread F starts after sunset and rapidly reaches a peak at about 2000 hours 75° EMT, falling off slowly toward morning. On disturbed days, spread F is apparently less than that on quiet days and the diurnal characteristic tends to attain a second peak after midnight. On magnetically stormy days, the behavior of spread F is somewhat variable. These phenomena are discussed in the light of the theory of spread F recently developed by Martyn (1959). Some of the observed characteristics of spread F over Trivandrum are in agreement with this theory.
A

RAO, E. Bhagiratha, and B. Ramachandra Rao. Diurnal variation of F_1 region drifts at Waltair. Current Sci. (India) 30, 9-10 (1961).

Gives an account of the year-round diurnal study of the F_1 region. Except for a few observations, the F_1 region drift measurements have not been reported so far from any other station. The present communication contains the results of F_1 regional diurnal study carried out for all the four seasons of the year, during the period of 1956-58, at Waltair, using the spaced receiver method of Mitra. The operating frequency for each observation took into account the critical frequencies of E and F_1 regions. At noon time the drift speed may be said to be a little higher than at other hours. A graph depicts the diurnal variation of F_1 drift direction for four seasons. In winter the F_1 drift was directed towards SW throughout the duration of 0800 to 1600 hours when observations were possible. In all the other seasons the drift direction was towards NE in the morning and evening hours.
MGA

RAO, E. Bhagiratha, and B. Ramachandra Rao. Travelling disturbances in the F-region over Waltair (India). J. Atmos. Terrest. Phys. 20, 296-297 (1961).

Travelling disturbances in the F-region have been studied extensively by Munro (1950, 1953) who has utilized the effect of these disturbances on

the P'-t records at three widely spaced points to study their horizontal movements. Abnormal patterns in the ionosonde records reported from some low latitude stations such as Singapore (Hon yung Sen, 1949; Osborne, 1951) and Ibadan (Skinner et al., 1954) were considered to be due to thick layer structure and stratification, but Munro and Heisler (1956) showed that these may be interpreted as due to a change of distribution of ionization due to the passage of a travelling disturbance. In this communication the authors present a description of the general characteristics of travelling disturbances as observed at Waltair on the P'-t and P'-f records.

Occurrence of travelling disturbances during night-time has not yet been reported by earlier investigators. The authors have been noticed that the travelling distrubances were observed at this station during the earlier part of the night. In all such cases it is found that the separation of o and x rays in small. Fig. 1(f) shows one such observation taken during the night with a y type complexity. It is interesting to note that the o ray and the complexity disappear abruptly at 1915 hours.
Excerpt

RAO, E. Bhagiratha, and B. Ramachandra Rao. Simultaneous study of drifts at different levels in ionosphere by spaced receiver method. J. Brit. Inst. Radio Engrs. 22, 507-510 (1961).

Results of simultaneous study c drifts in F1 and F2 regions of ionosphere measured at Waltair, India over period of 2 yr; F2 drift speeds are generally found to be higher than F1 drift speeds measured simultaneously; drift measurements in F2 layer are affected under certain circumstances by drifts in Es region.
EI

RAO, E. Bhagiratha, and B. Ramachandra Rao. Horizontal drifts in the ionosphere in relation to random fading. J. Sci. Indus. Res. 20B, 301-303 (1961).

Fading and drift measurements in the ionosphere, carried out for a period of two years (1956-58) at Waltair at frequencies of 4.6, 5.8, and 7.0 Mc/s, were analyzed. It was observed that a linear relationship exists between drift speed and fading frequency. The spread angles for the three frequencies 4.6, 5.8 and 7.0 Mc/s, which were found to be small, show a gradual decrease with increase in frequency. The possible reasons for obtaining spread angles lower than those reported by earlier investigators are given.
PA

RAO, G. L. Narayana, and B. Ramachandra Rao. World wide study of horizontal drift and anisotropy of ionospheric irregularities in the E-region. J. Atmos. Terrest. Phys. 25, 553-569 (1963).

An attempt has been made to study the latitude variation of anisotropy and drift parameters of ionopheric irregularities in E-region using IGY data of Waltair, Yamagawa, Debilt and Halley Bay. A systematic variation in most of the drift and anisotropy parameters is observed from equatorial to very high latitude stations with the exception of polar regions for which the values are found to be entirely different. Harmonic analysis of N–S and E–W components has shown that the semi-diurnal component is predominant in all stations except Waltair. The sense of rotation is found to be clockwise in northern hemisphere for all stations except Yamagawa and anti-clockwise in southern hemisphere. The results were compared with those of earlier investigations at different latitudes.
A

RAO, G. L. Narayana, and B. Ramachandra Rao. World wide study of apparent horizontal movements in F2-region of the ionosphere. J. Atmos. Terrest. Phys. 26, 213-229 (1964).

The paper presents the results of the study of latitude variation of apparent horizontal movements in the F2-region of the ionosphere using the data procured from the World Data Centre for the year 1958. The mean drift speed is found to decrease from equator and after reaching a minimum around a latitude of 40°, it increases. From the harmonic analysis of the NS and EW components the latitude variation of the prevailing 24-hourly and 12-hourly periodic components of the drifts has also been studied. The steady component is significant at all stations. The NS component of the steady drift is in general less than the EW component. The EW component of the steady drift is towards east at low latitudes and towards west at high latitudes, the changing over taking place at a geomagnetic latitude of about 30°N. The orientation of the steady drift vector changes systematically in a clockwise sense from low latitude to high latitude stations. The diurnal drift vector is very much larger than the semi-diurnal drift vector at low latitude stations whereas at middle and high latitude stations the semi-diurnal drift vector is greater than the diurnal drift vector. The 24-hourly drift vector which has a maximum value at the equator decreases with latitude and after reaching a minimum around 30° geomagnetic latitude it continues to increase. There is a systematic increase in the amplitude of the 12-hourly drift vector with increase of latitude. Both the 24- and 12-hourly drift vectors rotate clockwise in the northern hemisphere and anti-clockwise in the southern hemisphere.
A

RAO, K. S. Raja, and K. R. Sivaraman. Lunar geomagnetic tides at Kodaikanal. J. Geophys. Res. 63, 727-730 (1958).

Following the mathematical development of Chapman and Miller, Tschu has described a practical method of determining the lunar diurnal variation of geophysical elements. By the application of Tschu's method, the lunar semi-diurnal variation of the horizontal intensity of earth's magnetic field at Kodaikanal in the geomagnetic equatorial region is worked out for the winter solstice by making use of the hourly values of the horizontal intensity for the period 1950 to 1954.

The expression $\Delta H - 3.22 \sin (2\tau - 39° 04')\gamma$ is obtained for the lunar semi-diurnal wave. A graph of Δ H against the age of the moon is drawn. From the graph, it is seen that the amplitude of the lunar geomagnetic tide is maximum when the sun and the moon are 135° apart. The solar diurnal variation is also determined up to four harmonics.

A

RAO, K. S. Raja. On the seasonal variation in lunar and solar geomagnetic tides in the geomagnetic equatorial region. J. Atmos. Terrest. Phys. 20, 289-294 (1961).

Following the method outlined by Chapman and Miller (1940), the lunar L(H) and solar S(H) geomagnetic tides at Kodaikanal (geomagnetic latitude +0. 6°) are determined for the three seasons —December solstice, June solstice and equinox, making use of the hourly values of horizontal intensity for the years 1950-1955. The seasonal variation of the amplitude of L(H) at Kodaikanal is compared with similar results for Huancayo (geomagnetic latitude —0. 6°) and Ibadan (geomagnetic latitude +10°). It is seen that the amplitude of L(H) at Kodaikanal is larger in December solstice than in June solstice, similar to the variation at Huancayo and Ibadan. It is, therefore, concluded that the ionospheric currents causing geomagnetic tides are not symmetrical with respect to the geomagnetic equator; but the southern hemispheric currents extend into the northern hemisphere up to 10°N geomagnetic latitude in December solstice. It is likely that the region of separation of the northern and southern hemispheric currents is not static, but oscillates northwards and southwards across the geomagnetic equator. The type of seasonal variations in the amplitudes and phases of the lunisolar variations is markedly different from the variations in the higher latitudes. There is no significant seasonal variation in the amplitude of S(H) in the geomagnetic equatorial region.

A

RAO, K. S. Raja, and M. Panduranga Rao. On the location of the ionospheric current system causing geomagnetic solar flare. J. Atmos. Sci. 20, 498-501 (Nov. 1963).

The geomagnetic crochets recorded at Alibag, Annamalainagar and Trivandrum by the solar flare of 12 July 1961 are examined with reference to the normal S_q currents prevailing over these stations at the time of the solar flare. The large change in declination at Alibag and changes in horizontal intensity at Annamalainagar and Trivandrum indicate that the solar flare current system is an intensification of the normal S_q current system. Evidence in favor of this conclusion is sought for in the solar flare effects recorded at Alibag by the flares of 19 November 1949, 19 March 1948, and 14 October 1963. A plot of the amplitudes of the solar flare effects in the horizontal intensity at Alibag, Annamalainagar and Trivandrum during the period 1958-59 shows daytime enhancement of the flare effect at the latter two stations only, indicating a close connection between the crochet current system and the electrojet. It is therefore established that the crochet current system is an enhancement of the normal S_q current system.
PA

RAO, M. K., S. C. Mazumdar, and S. N. Mitra. Investigation of ionospheric absorption at Delhi. J. Atmos. Terrest. Phys. 24, 245-256 (1962).

An analysis has been presented in this paper of the measurements of ionospheric absorption taken at Delhi (28°35'N, 77°5'E) for the period 1954-1960. The measurements were carried out by means of an automatic absorption recorder where the ionospheric absorption was directly recorded on a pen and ink recorder. The analysis of the observed data indicates that the frequency variation of absorption obeys approximately an inverse square law. The diurnal variation factor for D-layer absorption is 0.77. Seasonal variation of absorption indicates higher absorption in winter than what one would normally expect from the diurnal variation factor. The relaxation time is approximately 40 min. A well-defined and consistent pre-noon maximum has also been observed about 40 min before noon. Residual absorption at night is quite low and is of the order of 2-3 dB. There is no significant relationship between magnetic activity and ionospheric absorption at Delhi. The decrease in absorption after the occurrence of a radio fade-out follows closely the change in the signal from the D-region of a distant longwave transmitter (164 kc/s) indicating that most of the absorption at our latitude is from the D-layer.
A

RAO, M. Mukunda, and B. R. Rao. The effect of electrojet on the seasonal variation of sporadic-E. J. Atmos. Terrest. Phys. 25, 571-576 (1963).

In the present communication, an attempt has been made to judge the extent of electrojet from the seasonal variation curves of f_0E_s. From the analysis of the E_s data for the Indian Ionospheric stations near the magnetic equator, it is noted that the change over from the tropical type of E_s to the equatorial type is observed to take place between magnetic dip 5° and 10°. The dependence of the electrojet on the sunspot activity as judged by the seasonal variation of E_s has also been studied.
A

RAO, M. N. and A. P. Mitra. Effect of vertical drifts on the nocturnal ionization of the lower ionosphere. J. Atmos. Terrest. Phys. 13, 271-290 (1959).

Effect of vertical ionic drift velocities on the night-time ionization density in the lower ionosphere for heights ranging between 80 km to 130 km is studied by a method of successive approximation. Values are also given of the effective recombination coefficient as a function of height and time for these drift velocities. Velocities ranging from 1 to 20 km/hr are used. The resultant ionization profiles for velocities 1-5 km/hr represent magnetically quiet conditions, while those for higher velocities would represent disturbed conditions of increasing severity. It will be noted that the ionization density decreases for upward drift and increases for downward drift.

The present work provides a quantitative explanation of the sudden cessation of night-time echoes of low-frequency radio waves at times of magnetic disturbances, such as those observed at the Pennsylvania State University (Lindquist, 1953).
A

RAO, M. Srirama, and B. Ramachandra Rao. Long-period fading in medium-wave radio signals. Nature 176, 459-460 (1955).

Fading of transmissions on 1.42 Mc/s from Madras received at Waltair, 600 km distant, in May 1954 showed a period of 7 min, decreasing with time (7 h to 8 h). This agrees with calculations based on magneto-ionic theory.
N

RAO, M Srirama, and B. Ramachandra Rao. Investigation of magneto-ionic fading in oblique incidence medium-wave transmissions. J. Atmos. Terrest. Phys. 12, 293-305 (1958).

Periodic fading of magneto-ionic origin observed in oblique incidence medium-wave records as interpreted theoretically by calculating the phase paths by a graphical integration method assuming Chapman and parabolic ion distribution. Analytical expressions have also been derived for phase paths of both magneto-ionic components by an approximate method involving the use of an empirical formula for q-x curves. The theoretical values of fading periods compared very well with the experimental data, the agreement being particularly good for the case of Chapman distribution.
A

RAO, M. S. V. Gopal, B. Ramachandra Rao, and P. Ramachandra Rao Pant. Fading of c.w signals as a means of spread F study. Current Sci. (India) 29, 304-305 (1960).

At night the fading rate of 11.7 Mc/s c.w. signals reflected obliquely from the F region is markedly increased when spread F conditions are observed by vertical incidence sounding.
PA

RAO, M. S. V. Gopal, B. Ramachandra Rao, and P. Ramachandra Rao Pant. Correlation of spread-F activity with F-region height changes. J. Atmos. Terrest. Phys. 17, 345-347 (1960).

A new scheme of spread-F indices is developed to suit the equatorial spread-F observations and applied to estimate the correlation coefficient between spread-F activity and F-region height changes.
A

RAO, M. S. V. Gopal, and B. Ramachandra Rao. Effects of equatorial spread-F irregularities on c. w. transmissions. Canad. J. Phys. 39, 596-603 (1961).

A study is made of the effects of spread-F conditions on c. w. transmissions between Colombo and Waltair over a distance of about 1300 km. It is shown that under suitable conditions increased fading rate of the received c. w. signals is a sufficient indication of spread F and gives a genuine index of its intensity. Pulse and c. w. methods are used simultaneously to study the time variations of spread-F intensity at separated points. The results indicate that the horizontal extent of spread-F occurrence in the N-S direction is greater than 650 km. The probability distributions of signal amplitudes in the c. w. fading records were closer to Rayleigh type under normal conditions than during spread-F conditions. It is suggested that the c. w. flutter fading is caused by the presence of spread-F irregularities in the appropriate zone of reflection in the F-region of the ionosphere.
PA

RAO, M. S. V. Gopal, and B. Ramachandra Rao. Nocturnal and seasonal variations of equatorial spread F. J. Atmos. Terrest. Phys. 22, 12-22 (1961).

A new classification of spread-F echo patterns based on the relative amplitudes of the echoes is described and discussed. The results of nocturnal and seasonal variations in spread-F at Waltair are presented and a comparison is made with data of other equatorial stations with particular reference to that of Kodaikanal. Differences in the seasonal behavior of spread-F within a geomagnetic latitude range of 0 to ±7° are considered in relation to the equatorial electrojet.
A

RAO, M. S. V. Gopal, and B. Ramachandra Rao. Equatorial spread F in relation to post-sunset height changes and magnetic activity. J. Geophys. Res. 66, 2113-2120 (1961).

Equatorial spread F, magnetic activity, and post-sunset rise in h'F are studied in detail as three parameters, and correlations in the variations in each of the three pairs are examined for all the seasons. Partial correlations are sought to examine the independent influence of magnetic activity and h'F changes on spread F. It is observed that the time of maximum spread F on each night is effectively controlled by the magnitude of the h'F change between 1800 and 1900 LT. The results are discussed in the light of the recent theory of spread F outlined by Martyn.
A

RAO, M. S. V. Gopal, and B. Ramachandra Rao. The correlation of spread on one night and the successive nights. Indian J. Phys. 36, 490-492 (1962).

A correlation of coefficients of spread-F on one night and the successive nights was estimated and it was found that it is positive and significant for a 24 hr time shift for Waltair data. Data for the first half night showed better correlation both for 24 and 48 hr time shifts. There is a distinct seasonal variation in the correlation. The correlation for Kodaikanal data is not significant for most of the year.
PA

RAO, M. S. V. Gopala, and B. Ramachandra Rao. Phenomena during the growth and decay of spread-F. J. Brit. Inst. Radio Engrs. 25, 445-448 (1963).

Continuous observations of the ionospheric echoes at the time of the onset of spread-F and during the decay of the same, yielded useful information. Two different types of spread-F onset are described. An attempt is made to find out whether the F-layer drift spreads measured by the three station method on 5.6 Mc/s at 1830 hours l.t. are related to the magnitude of spread-F that is likely to occur later in the night.
A

RAO, N. S. Subba, and Y. V. Somayajulu. A peculiar type of rapid fading in radio reception. Nature 163, 442 (1949).

While studying the field-strength variations at Waltair of transmissions from certain broadcasting stations of the All-India Radio, a peculiar type of rapid fading, which does not appear to have been reported so far, was observed during the summer months on the 41- and 60-metre bands. The phenomenon may briefly be described as the apparent existence on the carrier, at the receiving end, of a permanent modulation of 2-3 cycles per second. When the programme is on, there is superposed on it a variation in intensity at frequencies ranging between 2 to 3 cycles per second. This gives the impression of a quivering or fluttering of the transmission. This phenomenon is therefore referred to here as the 'flutter phenomenon'. The effect produced in the loud-speaker by the 'flutter' is somewhat similar to the beating of two notes of nearly the same frequency. When the quasi-frequency of the 'flutter' becomes large, it produces a most annoying effect,

and listening to a programme becomes almost impossible. The effect is further accentuated by occasional large amplitude of the 'flutter'.

A study of the phenomenon with respect to the evening and night transmissions of All-India Radio (Madras) showed the following features: (1) It occurs only during the summer months. In 1948 it started about the second week of February and continued to the end of June almost every day. (2) The 'flutter' appears at about the period of sunset. The quasi-flutter frequency is low (about 20-30 c./min.) before sunset, but increases (to 120-140 c./min.) up to a point in the night and thereafter remains practically constant.

Although this effect was observed on the Madras transmissions, it was noticed on the 41-, 49- and 60-metre bands transmissions from other stations of All-India Radio as well, and occasionally on the 19-metre band. It is completely absent on the medium wave-band.

A trace of galvanometer records incorporated in a field-strength measuring equipment is given in the accompanying diagram: curve (a) refers to All-India Radio (Madras) on 41 metres; curve (b) to the Colombo transmissions on 61 metres; and curve (c) refers to the transmission of All-India Radio (Trichinopoly) on 396 metres. The curves were taken at 2000 and 2045 hr. I.S.T., on June 16, 1948.

It is seen from the curves that there is a slow fading with periods ranging from 3 to 4 sec. giving rise to what clearly appears as the usual slow type of fading, the signal strength fluctuating between 2,000 μV./m. to 200 μV./m. Superposed on this are the small, fine discontinuities which make the trace appear rugged. It is this rugged structure which is noticed as the 'flutter'. At the point marked X, the number of these discontinuities is 12 in a period of 5 sec., that is, it occurs at intervals of approximately 0.5 sec. or at a frequency of about 140 cycles per minute.

The rugged structure of the curves reminds one of the irregular scatter groups obtained by Eckersley and the occurrence of flickering reflexions from the F-region reported by Beckmann, Menzel and Vibig. A peculiar type of rapid fading (about 37 cycles per minute) was observed by Appleton and Beynon during the period of sunset due to the reception of the Pedersen ray. The phenomenon described here is different from the above in that the rapid fading noticed by the above authors was only during a period of 14 min. passing through sunset; but the one described here commences about the period of sunset and persists over long periods. Therefore the ionosphere must in some way be responsible for the 'flutter' phenomenon, although the exact method of production of this effect is not known. If the rapid movement of the ionic clouds across the F-layer is a regular process as observed by Wells, Watts and George, the effect reported above may be produced by these clouds. The speed and the number of clouds that pass a given point in space may to a large extent determine the frequency of the rapid fading produced.

Complete

RAO, N. S. Subba, and Y. V. Somayajulu. The influence of weather conditions on long distance short wave transmission. Proc. Indian Acad. Sci. A 31, 42-55 (1950).

The field strengths at Waltair, of signals radiated from Madras, Calcutta and Bombay stations of the All India Radio on the 41 and 49 m bands, have been studied over a period of 7 months. The measurements have been made between 7.30 hr to 9.00 hr Indian Standard Time daily. The day-to-day variations of the field strengths of the received signals are presented, month by month, in the form of graphs and discussed. The study of these curves shows that: (1) During the wet season there is a definite relationship between the field strengths of the received signals and the percentage humidities in the atmosphere along the path of the wave—a rise or fall in humidity producing a corresponding fall or rise in the received signal strengths. (2) Further, these effects are more pronounced when the percentage humidities are 85%. (3) In cases where the humidities are much lower, there appears to be no relation between these two quantities. This abnormal transmission, especially during the wet season, is traced to reflection at low levels, produced by clouds or zones of condensation or by water vapour molecules themselves.
EEA

RAO, P. Balarama, and B. Ramachandra Rao. Height variation of drift and anisotropy of the ionospheric irregularities. J. Atmos. Terrest. Phys. 26, 231-238 (1964).

The variation of drift and anisotropy characteristics of the ionospheric irregularities with true height has been studied following the "correlation function method" of Briggs et al. and Phillips and Spencer. Three station fading records on various frequencies adopting Mitra's technique, as modified by Rao, Rao and Murthy, are obtained on nine different occasions and these are utilised in the present investigation. Various parameters describing the drift and anisotropy of the irregularities are averaged from total data for different height levels and are presented along with the results of their gradient in the form of tables. The results which revealed a distinct

maximum in the random changes as well as in the elongation of the irregularities in the height range of 200-300 km, suggest that this height range may be the possible location of the irregularities causing spread-F and radio star scintillation.
A

RAO, P. Balarama, and B. Ramachandra Rao. Seasonal and diurnal variation of the drift and anisotropy parameters of the irregularities in the E and F regions of the ionosphere. Proc. International Conference on the Ionosphere, London, July 1962, 363-369 (The Institute of Physics and the Physical Society, London, 1963).

The correlation analysis of Briggs et al. (1950) and Phillips and Spencer (1955) has been applied to the fading of radio waves reflected from the E and F regions, observed at three closely spaced receivers. Histograms are presented to show the distribution of occurrence of various parameters describing the ground diffraction pattern. The importance of random changes relative to pure drift in producing the fading is also indicated.
A

RAO, P. Balarama, and B. Ramachandra Rao. Effect of magnetic activity on drift and anisotropy of the E- and the F-region irregularities. J. Atmos. Terrest. Phys. 26, 445-456 (1964).

In this communication are presented the results obtained from the correlation analysis of the three station fading records taken during magnetically disturbed conditions for the E- and the F-region reflections. The results of the present investigation are compared with those reported by Rao and Rao (1962) for magnetically quiet conditions. Diurnal curves for various parameters are presented along with that of the magnetic K index with a view to studying the variation in relation to the magnetic activity. The relation between the drift speeds at the E- and the F-region levels and the magnetic K index has also been studied by means of correlation coefficients using a large number of observations taken over magnetically quiet as well as disturbed conditions. The effect of magnetic activity on various parameters observed at this low latitude station are discussed in the light of the results reported from a similar study at Cambridge by Fooks (1961).
A

R

data is utilized as it has been observed that night-time reflections from the E_s-region do not show any appreciable variation in the reflection level. Day-time drift speeds in the E-region show very little variation, and since the analysis is made by considering a large number of day-time observations together, minor diurnal and seasonal variations are smoothed out. In view of the fact that E-region drift speeds at Waltair show a positive correlation with magnetic activity as reported by Rao and Rao (1961) only quiet day observations are utilized in this study. The drift speed data is grouped into three virtual height ranges corresponding to 95-105, 105-115 and 115-125 km and the averages of the drift speeds in each of these groups are taken to correspond to the virtual heights of 100, 110 and 120 km. The results thus obtained are given in Table 1 along with the gradients estimated for the two height ranges of 100-110 and 110-120 km. The average gradient for the entire height range is 0. 74 m/sec/km. Although there is indication of a slightly lower gradient at higher levels, this result may not be regarded as significant in view of the fact that only approximate values of virtual heights are used.

Estimates of height gradients of drift speed are available for the height range of 80-100 km by the meteor method. Greenhow (1955) has obtained a value of 2. 5 m/sec/km, and Elford and Robertson (1953) reported a value of 3. 6 m/sec/km. The result obtained in the present investigation is less than that obtained by the meteor method. Winkleman (1956 reported a value of 4. 9 m/sec/km for the height gradient of drift speed by the spaced receiver method from observations on a frequency of 310 kc/s taken on eleven nights. Considering the fact that our observation at Waltair refers to higher levels and a lower latitude, complete agreement with the few results so far reported from higher latitude stations is not expected.

Results from other lower latitude stations are not available for comparison.

Excerpt

RASTOGI, R. G. Intermediate layers of ionization between the E and F1 layers of the ionosphere over Ahmedabad (23°N, 72°E). Proc. Indian Acad. Sci. 40, 158-166 (1954).

Plots observed penetration frequency and virtual height for ionospheric layers, including E2. Says critical frequencies for E2 vary with cosine of solar zenith angle to power 0. 38. Finds true heights correspond well with heights of ionization maxima determined from rocket data.

M

RASTOGI, R. G., and R. M. Sheriff. A note on radio field strength observations made at Ahmedabad during the total solar eclipse on 30 June 1954. J. Sci. Indus. Res. 14A, 159-161 (1955).

In order to study the effects of the solar eclipse on 30 June 1954 on the propagation of radio waves, the field strengths of the transmissions from the British Broadcasting Corporation (London) on 15.07 Mc/s. and from Moscow on 15.36 Mc/s. were recorded at Ahmedabad (23°02'N, 72°38'E) during the eclipse day and a few days before and after it.

The readings were taken every half a minute. During rapid fadings, the average meter readings were noted. The meter readings were converted into signal input voltage, and they were averaged for every 5 min. period. Signal strength (5 min. average) was plotted against time on all control days and on the eclipse day. The curves for all the control days were similar except that for 3 July 1954. The field strengths on that day were markedly higher than those on the other control days and were, therefore, not included for averaging.
Excerpt.

RASTOGI, R. G. The occurrence of high multiple reflections from the F2 region of the ionosphere based on a study of the Ahmedabad records. Proc. Indian Acad. Sci. 41, 253-260 (1955).

Shortly after the installation of the automatic ionospheric recorder at Ahmedabad in January 1953, it was observed that on certain nights groups of pulses other than the regular ones moved swiftly across the time base on the monitor oscilloscope. On the P'-f records, they produced traces which started from below the ground pulse and crossed the various P'-f traces. Examples of such records are shown in Fig. 1. After the first three months of regular P'-f recording, the phenomenon was not observed for some months, but reappeared clearly in December 1953 and January 1954. A study of the phenomenon was then undertaken.
A

RASTOGI, R. G., R. M. Sheriff, and N. G. Nanda. Some measurements of the signal strengths of radio waves reflected from the ionosphere during the solar eclipses of 30 June 1954 and 20 June 1955 - Solar Eclipses and the Ionosphere supplement, J. Atmos. Terrest. Phys. 6, 137-142 (1956).

The signal strengths of radio waves from B.B.C. transmissions on 15.07 Mc/s were measured at Ahmedabad during the 1954 eclipse, with control observations on a few preceding and succeeding days. The signals, which could have been either by two-hop or three-hop reflections, showed well-marked increases in intensity during the eclipse. The increase

of signal strength is considered to be due to a decrease of attenuation in the F1-layer. Similar measurements were carried out for the 1955 eclipse at Trivandrum, on the radio transmission from Colombo on 4.87 Mc/s directed skyward, and at Ahmedabad on 7.19 Mc/s. Here again the signals showed well-marked increases of strength during the eclipse. In both cases the signal intensity returned to its normal value well before the end of the eclipse. The reflections observed at Trivandrum could have been from F1, if there was an F1-layer. Near the geomagnetic equator, however, F1 is not usually observable at this hour of the day. Probably the reflection took place from F2, with decrease of attenuation mainly in F1. The reflections observed at Ahmedabad should have been from E, and the decrease of attenuation during the eclipse should have taken place below F.
PA

RASTOGI, R. G. Two types of development of the E2 layer at Ahmedabad. J. Atmos. Terrest. Phys. 9, 71-72 (1956).

The sequence of phenomena leading to the separation of the E2 layer in the morning hours after high-level sunrise indicates the presence of certain atmospheric constituents in the neighbourhood of 150 km which are photo-ionized by the solar radiation. Further, the frequent appearance of a stratified ionized layer at 150 km during night indicates that there exists a sensitive and stable region for the formation of an ionized layer at about 150 km over the tropics.
N

RASTOGI, R. G., and R. Sethuranam. Field strength measurements of radio waves during the partial solar eclipse of 14 December 1955 at Ahmedabad. J. Sci. Indus. Res. 15A, 303-305 (1956).

Measured field strength of obliquely reflected radio waves during 2 solar eclipses. On 7 Mc/s, field strength went down, on 9 Mc/s went up. Relates to vertical incidence frequencies.
M

RASTOGI, R. G. Vertical ionospheric soundings at Ahmedabad during total solar eclipse on 30 June 1954. Proc. Indian Acad. Sci. 46, 422-429 (1957).

No abstract available.

RASTOGI, R. G. Thunderstorms and sporadic E layer ionisation, Indian J. Met. Geophys. 8, 43-54 (Jan. 1957).

The paper describes the results of vertical P'-f recordings of ionospheric reflections carried out during the passage of thunderstorms over Ahmedabad. The thunderstorms were found to be accompanied by an increase in sporadic E ionization as shown by a rise in the maximum frequency of the Es or an increase in the intensity of reflection from Es.
A

RASTOGI, R. G. On the variation of noon and sub-solar critical frequency of the E and F_1 layers of the ionosphere with solar activity. Proc. Ind. Sci. Congr. Session, Calcutta. Part IV, 49 (1957).

No abstract available.

RASTOGI, R. G. Vertical ionospheric soundings at Ahmedabad during partial solar eclipse on 14 December 1955. Proc. Indian Acad. Sci. 47A, 65-76 (1958).

Results of critical frequency and minimum equivalent height measurements for all the layers observed at Ahmedabad are given. The variation was roughly consistent with that of a Chapman layer with $\alpha \sim 0.8 \times 10^{[illegible]}$. There was no clear effect of the eclipse on the E1 and E2 layers, although the critical frequencies were in general lower on the eclipse day; the Es layer was unaffected. The variation of f_0F1 was irregular but showed a decrease; f_0F2 was higher on the eclipse day than on the control days, but the rate of increase of f_0F2 was reduced. There were indications of the formation of an F1 1/2 layer during the latter part of the eclipse.
PA

RATOGI, R. G. A study of the noon critical frequencies of the E and F1 layers of the ionosphere. Geofis. Pura e Appl. 40, 145-156 (1958).

The mean monthly noon critical frequencies of the E and F1 layers of the ionosphere at a number of stations in different latitudes and their variation with sunspot number have been studied in this paper. It is found that while the E layer approximates to a Chapman region, the F1 layer is markedly affected by other agencies, somewhat similar to F2. In high sunspot years, f_0F1 shows two maxima at middle latitudes with a minimum at the equator.
A

RASTOGI, R. G. Vertical ionospheric soundings at Ahmedabad during the partial solar eclipse of 19 April 1958. J. Sci. Indus. Res. 18A, 123-126 (1959).

The changes in the ionospheric layers are described. The critical frequencies of the F2 layer show a large depression during the eclipse compared with control days. The E and E2 layers show effects similar to the F2 layer, but much feebler. The changes in the F2 layer were found to be mainly due to the lowering of the layer peak. The changes in the F2 layer during this eclipse are compared with those of other solar eclipses which occurred in the forenoon hours.
PA

RASTOGI, R. G. Magnetic control on the variations of the critical frequency of the F2 layer of the ionosphere. Canad. J. Phys. 37, 874-879 (1959).

The paper discusses the comparative influence of the true magnetic and smooth geomagnetic latitudes on the diurnal and latitudinal variations of the critical frequency of the F2 layer (f_0F_2) at low latitudes. The diurnal variations of f_0F_2 are shown to differ considerably at stations having the same geomagnetic latitude, but the discrepancies disappear when the true magnetic latitude is taken into consideration. The latitudinal variation of noon values of f_0F_2 is also shown to present discrepancies for low latitude stations in the geomagnetic latitudes plot, but on true magnetic latitude plots the points fall regularly along a smooth curve.
A

RASTOGI, R. G. Geomagnetic influence on the F1- and F2-regions of the ionsphere-effect of solar activity. J. Atmos. Terrest. Phys. 14, 31-40 (1959).

The paper discusses the geomagnetic influence on the noon critical frequencies of F1- and F2-layers in different seasons and at different stages of solar activity. The F1-layer is found to be affected by the magnetic field only in years of high solar activity. The equatorial depression of noon f_0F2 is, on the other hand, most prominent in years of low solar activity.
A

RASTOGI, R. G. The diurnal development of the anomalous equatorial belt in the F2 region of the ionosphere. J. Geophys. Res. 64, 727-732 (1959).

The latitudinal variation in the critical frequency of the F2 layer was studied for each hour of the day during the equinoctial months of a year at sunspot minimum. The middle latitude maxima first develop at low latitudes and shift poleward with the progress of the day, the course being reversed in the evening hours. The double maxima in the diurnal variation of f_0F2 are less separated with increasing latitude and finally converge to a single maximum at a dip of about 25°. These two anomalies in f_0F2 are suggested as being due to the vertical drift of ionization, together with its motion towards the poles in the morning and towards the equator in the afternoon. Other anomalies of F2 can also be explained by a meridional transport of ionization.
A

RASTOGI, R. G. A synoptic study of the F2-region of the ionosphere in the Asian zone. J. Atmos. Terrest. Phys. 18, 315-331 (1960).

A detailed study of the variation of f_0F2 at ionospheric stations in the Asian zone shows that the region of maximum f_0F2 varies with the time of the day as well as with the season. The anomalous belt of the F2-layer develops at the equator near sunrise and slowly expands with the progress of the day, and is most extended during the afternoon hours.

Multiple splittings in the F-region and other abnormal P'-f recordings observed at middle latitudes are shown to be associated with some striking features in the synoptic distribution of f_0F2. The abnormal recordings can be explained on the basis of horizontal movements in the ionosphere, being in the east-west direction before sunrise in the morning or after sunset in the evening, and in the north-south direction during the forenoon.
A

RASTOGI, R. G. Abnormal features of the F_2 region of the ionosphere at some southern high-latitude stations. J. Geophys. Res. 65, 585-592 (1960).

The variation of the midday value of the critical frequency of the F_2 layer (f_0F_2) with magnetic dip shows asymmetry between the northern and southern stations of the west (American) zone, but not of the east zone. The control by the earth's magnetic field is indicated in the latitudinal distribution of even the midnight values of f_0F_2. The diurnal variation of f_0F_2 at Port Lockroy shows abnormal minimum at midday and maximum at midnight during the summer months. These abnormal features of the F_2 layer at Port Lockroy are explained on the basis of the horizontal transport of ionization as guided by the earth's magnetic field.
PA

RASTOGI, R. G. Asymmetry between the F_2 region of the ionosphere in the northern and southern hemispheres. J. Geophys. Res. 65, 857-868 (1960).

The paper describes the asymmetry in the seasonal variations of the critical frequency of the F_2 layer at high-latitude stations in the northern and southern hemispheres during the years of minimum sunspot number. The variations of the F_2 layer at pairs of stations similarly situated on opposite sides of the equator are studied for different hours of the day and for different stages of solar activity. During years of low sunspot number, the curves of seasonal variations of f_0E, f_0F_1 as well as f_0F_2 are very similar to each other, and the well known summer decrease of noon f_0F_2 is not present at southern stations. The various hypotheses advanced to explain the abnormalities in the F_2 region are examined to explain the asymmetry, and a plausible cause is suggested on the basis of wind systems in the F_2 region, mainly the horizontal transport of the ionization.
A

RASTOGI, R. G. Propagation of radio waves reflected from the ionosphere during solar eclipses. Geofis. Pura e Appl. 45, 123-152 (1960).

No abstract available.

RASTOGI, R. G. Lunar tidal variations in the critical frequency of the F_2 layer at equatorial and tropical latitudes. Symposium on Ionospheric Soundings in the IGY/IGC, 11-16 Dec. 1961.

No abstract available.

RASTOGI, R. G. The morphology of lunar semi-diurnal variation in f_0F2 near solar noon. J. Atmos. Terrest. Phys. 22, 290-293 (1961).

The variations of the midday critical frequency of the F2-layer, f_0F2, with the phase of the moon are computed for eighteen stations within about ±40° latitude during a period of low sunspot activity. The results show that the phase of the lunar variation of f_0F2 is determined by the magnetic and not by the geomagnetic or the geographic latitude. The reversal from the equtorial type of variation with a maximum near 04 lunar hour to the higher latitude type with a maximum near 10 lunar hour occurs at about ±11° magnetic latitude. The variation of amplitude with latitude shows a sharp maximum on the magnetic equator, associated with the equatorial electro-jet, and two broad maxima at about ±20° magnetic latitude. The latter are closely associated with the well-known maxima in the variation of noon f_0F2 with latitude.
A

RASTOGI, R. G. Lunar tide in the F2 layer of the ionosphere near the geomagnetic equator. Nature 189, 214-215 (1961).

Analysis of the lunar variation of f_0F2 at Leopoldville show that it is completely out of phase with that at any other equatorial station, but is very nearly the same as that at Ahmedabad. This suggests that similar lunar variations of f_0F2 occur at stations having the same magnetic latitude rather than the same geomagnetic latitude.
PA

RASTOGI, R. G. Some effects of geomagnetic activity on the F2 region of the ionosphere over Leopoldville (4.4°S, 15.3°E). Proc. Indian Acad. Sci. A 54 155-160 (1961).

In view of the large differences between variations in f_0F2 at Ibadan and Leopoldville a study of the effect of geomagnetic disturbances at these two locations was made. Curves showing the variation, with time, of NmF2, h'F2, hmF2 or hpF2 on both quiet and disturbed days are given for the two stations. At Ibadan values of NmF2 are greater on disturbed days whilst hmF2 takes higher values on quiet days. There is little difference between the NmF2 values at Leopoldville on quiet and on disturbed days. The values of HpF2 at Leopoldville show an opposite variation to the values of hmF2 at Ibadan. By considering the ionospheric parameters of other locations it is concluded that it is the magnetic and not the geomagnetic latitude that is of importance from the point of view of the effect of geomagnetic disturbances on the F2 layer.
PA

RASTOGI, R. G. Abnormal variations in the earth's magnetic field and the ionizations in the F_2 and Es regions of the ionosphere over central Africa. Abstract accepted by Commission III, URSI, Fall Meeting Austin, Texas, 1961.

The geomagnetic and magnetic equators of the earth are most separated from each other between the longitude ±30°. Consequently the geomagnetic and magnetic latitudes of some of the ionosphere stations in central Africa differ from each other by as much as 16°. A synoptic study of the ionospheric variations at central Africa stations shows the complete inadequacy of the geomagnetic latitude to explain the variations.

The solar and the lunar variations of f_0F2 at Leopoldville, Lwiro and Nairobi are distinctively the same as observed at other tropical latitude stations, though the geomagnetic latitudes of these stations are about 3-4°S.

Disturbance daily variations or the storm-time variations of f_0F2 at these stations show all the features observed at other high latitude stations.

It is shown that the variations of F2 and Es layer ionizations are consistent with the magnetic and not with the geomagnetic latitude.
A

RASTOGI, R. G. Longitudinal variation in the equatorial electrojet. J. Atmos. Terrest. Phys. 24, 1031-1040 (1962).

The enhancement of the diurnal range of the horizontal component (H) of the earth's magnetic field over the magnetic equator, believed to be due to the equatorial electrojet, is shown to be most pronounced in the American Zone and least in the Indian Zone, using the data contained in Egedal's report to IATME, observations by Pramanik et al. [Indian J. Meteorol. Geophys., Vol. 4, 353 (1953)] for the Indian zone, and the data at various other observatories collected during the IGY. The maximum value of the diurnal range in H in each of the zones occurs at a station closer to the magnetic rather than to the geomagnetic or the geographic equator. An approximately inverse relationship is found to exist between the diurnal range and the average value of H at the magnetic equator. The longitudinal variation of the ionospheric conductivities, due to the varying intensity of the earth's magnetic field over the magnetic equator, is found to be too small to explain the longitudinal inequalities in the electrojet Non-uniformities in the distribution of tidal velocities and/or of ionization densities in the ionosphere over different parts of the earth seem, therefore, to be necessary to produce the observed longitudinal variation in the equatorial electrojet.
A

RASTOGI, R. G. The effect of geomagnetic activity on the F_2 region over central Africa. J. Geophys, Res. 67, 1367-1374 (1962).

This article describes the variations of f_0F_2 at stations in central Africa, where the geomagnetic and magnetic equators are greatly separated from each other. At Lwiro and Leopoldville (geomagnetic latitude Φ = 3-4°S , magnetic latitude μ = 16-18°S), the diurnal variations of f_0F_2 show a single and strong maximum in the afternoon hours. The seasonal variation of noon $h'F_2$ at these stations has one single maximum during local summer. An increase of magnetic activity causes a decrease of the daytime values of f_0F_2 during local summer months, but it increases the same during local winter months. The storm-time variations of f_0F_2 at these stations show a short initial increase with the start of the magnetic storm followed by a large decrease on the second day of the storm. These properties of f_0F_2 are very similar to those observed at temperate latitude stations. The variations of f_0F_2 at Djibouti (Φ = 7°N, μ = 3°N) and Ibadan (Φ = 11°N, μ = 3°S) are very different from those at Lwiro or

Leopoldville and are of the equatorial type. It is concluded that the variations of f_0F_2 at low and medium latitudes are determined by the magnetic and not by the geomagnetic latitude of the station.
A

RASTOGI, R. G. Enhancement of the lunar tide in the noon critical frequency of the F_2 layer over the magnetic equator. J. Res. NBS 66D, 601-606 (1962).

The lunar semi-diurnal variations in the midday values of the critical frequency (f_0F2) and the height of the maximum electron density are derived for the two chains of equatorial stations in South America and India for the period 1957-58. The latitudinal variation of the amplitude of the lunar semi-diurnal variation in f_0F_2 shows a sharp maximum over the magnetic equator in both of the longitude zones. There is an indication of systematic variation in the amplitude with longitude along the magnetic equator, the maximum occuring in the South American zone (about 0.63 Mc/s) and the minimum in the Indian zone (about 0.33 Mc/s). Similar longitudinal variations were indicated in the lunar semidiurnal variations of the horizontal component of the Earth's magnetic field. The latitudinal variation of the amplitude of the lunar semi-diurnal variation of h_pF_2 is opposite to that of f_0F_2. The enhancement of the lunar variation in the F_2 layer ionization over the magnetic equator appears to be associated with the equatorial electrojet.
PA

RASTOGI. R. G. Longitudinal inequalities in the lunar tide and in sudden commencement in H near the magnetic equator. J. Atmos. Terrest. Phys. 25, 393-397 (1963).

Abnormally large amplitude of lunar semi-diurnal (L_2) variation in the horizontal component of earth's magnetic field (H) has been found at equatorial stations viz. Huancayo (Bartels, 1936) Kodaikanal (Raja Rao and Sivaraman, 1958) and Ibadan (Onwumechilli and Alexander, 1959a). It was suggested by Onwumechilli and Alexander (1959b) that large lunar effects in the horizontal component, H, and the vertical component, Z at Ibadan are due to augmentation of the equatorial electrojet. This has been further confirmed by Forbush and Casaverde (1961) for the equatorial magnetic stations operating during IGY in Peru. Rastogi (1963) has shown that the latitudinal variation in the amplitude of L_2 oscillation in H is very similar to that of solar diurnal (Sq) variation in H, and thus the enhanced lunar tide in H at the magnetic equator is closely associated with the electrojet currents.

Ferraro and Unthank (1951) noted the similarity in the solar diurnal variations in the average size of sudden commencement (SC) of H and of H itself. Comparing the sizes of SC at Huancayo and Cheltenham, stations on the same meridian but at different latitudes, Suguira (1953) noted a considerable enhancement in the size of daytime SCs near the geomagnetic equator. Ferraro (1954) found that apart from Huancayo, other stations eg. Cheltenham; Tucson, San Juan, Honolulu and Watheroo do not show any exceptional daytime enhancement of SC. The enhancement of SC amplitude has been found at other equatorial stations also (Srinivasamurthy, 1960, Maeda and Yamamoto, 1960). It has been suggested by Forbush and Vestine (1955) that the enhancement of daytime SCs at Huancayo is closely associated with the electrojet effects responsible for the large diurnal variation in H there.

Rastogi (1962a, b) has shown pronounced longitudinal inequalities in the strength of the electrojet, being strongest in the American zone. It has been sought in the present article if these longitudinal inequalities in the electrojet are reflected in the previously described effects which are associated with the electrojet.

To determine the lunar tide in geomagnetism we use the range of H defined as the average value of H between 1000 and 1400 hours L.S.T. minus the average value of H for the two intervals 0000-0100 and 2300-2400 hours L.S.T. The range in H on magnetically undisturbed days of the IGY and IGC, when the international character figure C was less than 1.2, were arranged into twelve groups according as the lunar phase μ or μ - 12 was 0, 1, 2...11. Variations with the lunar phase of the average deviation in the range of H during different seasons for Huancayo and Trivandrum are shown in Fig. 1. The dashed line in the diagram indicates the lunar semi-diurnal (L_2) variation derived from the harmonic analysis. The amplitudes and phases of L_2 variation in range of H for Huancayo and Trivandrum for different seasons are given in Table 1. The phases are given as the lunar hour when the deviation reaches its maximum positive value. The probable error in amplitude and phase are calculated according to method given in Rastogi's paper (1962a).

Referring to Fig. 1 it is noted that the amplitude of L_2 variation in the range of H for any particular season is larger at Huancayo than at Trivandrum; the phases are however almost the same as the two stations during the same season. The annual average amplitude for Huancayo is 15.6γ occurring at 8.6 lunar hour compared to 7.8γ at 9.6 lunar hour for Trivandrum. It is noteworthy that at both stations the amplitudes are about twice as large during December solstice than during June solstice, inspite of the fact that Huancayo and Trivandrum are in opposite hemispheres and have different local seasons during the same solstice. This suggests the existence of an annual effect in the seasonal variation of lunar tide in the range of H at the magnetic equator

Table 1. Coefficients of lunar semi-diurnal variation in the solar diurnal range of H at Huancayo and Trivandrum during IGY and IGC

	Huancayo July 1957-Dec. 1959	Trivandrum Oct. 1957-Dec. 1959
1. Annual average		
Average range (γ)	167	127
Amplitude (γ)	15.6	7.8
Phase (Lunar hr.)	8.6	9.6
2. December solstices		
Average range (γ)	158	108
Amplitude (γ)	26.1 ± 2.5	11.8 ± 1.8
Phase (Lunar hr.)	7.7 ± 0.2	7.7 ± 0.2
3. Equinoxes		
Average range (γ)	196	149
Amplitude (γ)	22.2 ± 2.0	13.9 ± 1.8
Phase (Lunar hr.)	8.8 ± 0.2	10.5 ± 0.3
4. June solstices		
Average range (γ)	147	123
Amplitude (γ)	7.6 ± 1.6	5.9 ± 1.9
Phase (Lunar hr.)	11.0 ± 0.4	10.9 ± 0.3

with the maximum during the December solstice. It is concluded that the lunar tide is much larger at Huancayo than at Trivandrum just as the longitudinal variation in the strength of the electrojet current at the two places.

Next, the amplitudes of individual sudden commencements in H observed at Huancayo and Kodaikanal during the period 1951-61 are plotted against the local mean time in Fig. 2. These data are taken from various publications of solar and geomagnetic data in Journal of Geophysical Research and in Indian Journal of Meteorology and Geophysics. The number of storms included in the diagram is 170 for Huancayo and 155 for Kodaikanal.

The enhancement of the SC amplitude during the daytime is clearly shown for both Huancayo and Kodaikanal. The average amplitude shows a continuous increase with time after 0600 hours, reaches a maximum around noon, after which it decreases till about 1800 hours and remains almost constant during the whole night time. The night time values of the

amplitude of SC are not significantly different at the two stations, the mean value for all the night hours being 28γ for Kodaikanal and 32γ for Huancayo. The daytime values of SC amplitude, on the other hand are much larger at Huancayo than at Kodaikanal. The average value of SC amplitude for the noon hour is about 120γ at Huancayo and only 70γ at Kodaikanal. There are two instances of SC exceeding 130γ at Kodaikanal, but there are about sixteen instances of similar SC's at Huancayo. The largest SC observed at Kodaikanal at 1301 hours L.M.T. on July 8, 1958 had an amplitude of 176γ. The largest SC at Huancayo at 1316 hours L.M.T. on November 6, 1957 had an amplitude of 355γ, there were seven other SC's exceeding 176γ occurring between 0900 and 1300 hours L.M.T.

There is a great scatter of points in both the diagrams in Fig. 2. For any hour, the amplitudes were generally larger during periods of greater sunspot number. To elucidate sunspot variation in the SC amplitude, the individual values of SC amplitude are plotted against the monthly average Zurich sunspot number (R_z) in Fig. 3 separately for the night time (2100-0300 hours L.M.T.) and daytime (0900-1500 hours L.M.T.) sudden commencements. The increase of SC amplitude with R_z is clearly indicated for both Huancayo and Kodaikanal. Assuming a linear relation between the amplitude (A) and sunspot number (R_z) [$A = a + bR_z$], the coefficients a and b are calculated and given in Table 2.

Table 2. Coefficients of the relation of SC amplitude (A) with Zurich sunspot number (R_z) according to the equation $A = a + bR_z$

	Day-time		Night-time	
	Huancayo	Kodaikanal	Huancayo	Kodaikanal
a.	45.0	17.9	20.0	11.9
b.	0.60	0.34	0.17	0.17

The night time values of SC amplitude for any fixed sunspot number are only slightly larger at Huancayo than at Kodaikanal and the increase of amplitude with sunspot is quite small for any of the stations. The day time values of SC amplitude for any fixed, R_z, as well as its sensitivity to increase of R_z are significantly larger at Huancayo than at Kodaikanal.

Maeda and Yamamoto (1960) have studied the diurnal variation of the amplitude of SC's at some equatorial stations for IGY period. They concluded that the daytime enhancement of SC's occur at stations less than about 20° dip and an abnormally large amplitude appears at stations very

close to the equator. From the diagram given in their paper it can be seen that the ratio of SC amplitude at midday to that at midnight was about 8-9 at Huancayo, 5-6 at Jarvis and 4-5 at Koror Island, all these stations being within 3° dip. Rastogi (1962b) has shown that for the IGY period the range of H was larger at Huancayo than at Jarvis Island or Koror Island. Therefore there is a definite indication that the daytime enhancement of SC's is much more pronounced at Huancayo than at other equatorial stations.

It is concluded that there exists large longitudinal variation along the magnetic equator in the daytime enhancement of the amplitude of sudden commencement, and in the lunar tide in range of H similar to the longitudinal variation in the strength of the electrojet as earlier indicated (Rastogi, 1962b).

Excerpt

RASTOGI, R. G. <u>Large lunar tidal effects in f_0F2 in presunrise hours.</u>
J. Atmos. Terrest. Phys. <u>25</u>, 515-158 (1963).

The analyses of the critical frequency of the F2 layer of the ionosphere, f_0F2, at Huancayo and Canberra for lunar tidal variations (Martyn 1947, 1948) have shown that both the phase and amplitude of the lunar semi-diurnal variation L2, depend significantly on the solar time.

Burkard (1951) found that the amplitude of L2 variation in f_0F2 at Huancayo calculated from noon values was about four times larger than that derived from all-day values. Further, it was found that night time f_0F2 did not show any significant lunar tidal variations. The analysis of f_0F2 at Ibadan by Brown (1956) shows that the amplitude of L2 variation is 0.119 Mc/s for all-day f_0F2 and 0.333 Mc/s for 1100-1300 hours mean f_0F2. Similarly the amplitude of L2 variation in f_0F2 at Leopoldville was found to be 0.33 Mc/s for midday values (Rastogi 1961a) and only 0.08 Mc/s for 24-hour values (Bossolasco and Elena 1960). These results show that the lunar tidal effect in f_0F2 is more pronounced during daytime than during night time.

Rastogi (1961b) has shown that the amplitude of L2 in midday value of f_0F2 is very large at magnetic latitudes 0° and ±20°. Comparing the solar diurnal variations of f_0F2 on groups of days having certain defined phases of the moon it has been estimated (Rastogi 1963) that the maximum effect of lunar tide in f_0F2 at equatorial stations occurred at or slightly before noon, whereas at higher tropical latitudes the maximum lunar tide in f_0F2 occurred in the afternoon at 1400-1500 solar hours.

Recently, Lange-Hesse and Schott (1962) computed the lunar variations in f_0F2 at Lindau during different times of the day. They found that the amplitude of L2 variation in the lowest value of f_0F2 during the hours before sunrise was 1.8 percent whereas the amplitude in the 1000-1400 hours mean value of f_0F2 was only 0.67 percent. It may be mentioned that Burkard (1951) had considered the L2 variation in f_0F2 at Huancayo between

2100 hours and 0800 hours and found that it was only at 0500 hours that the amplitude was greater than the radius of the error circle.

In this article are described some features of the solar time effects on the lunar tidal variations in f_0F2 at low latitude station, Nhatrang. The amplitude and phase of L2 variations in f_0F2 were derived as described in earlier papers (Rastogi 1961b, 1962). In Fig. 1 are shown the average solar diurnal variation for the period 1951-55 in f_0F2 and the amplitude of lunar semi-diurnal variation in f_0F2 expressed in Mc/s and also as a percentage of the mean value of f_0F2. As shown by Rastogi (1960) Nhatrang is within the anomalous equatorial belt of the F2-region and one finds during the day two maxima in f_0F2 with a bite out at noon. The amplitudes of L2 variation in f_0F2 are seen to be quite large during the daytime hours. The maximum ampitude of 0.40 Mc/s or 5.0 percent occurs at 1000 hours close to the time of maximum bite out effect. Besides the midday peak one finds another maximum during the morning hours at 0500 hours, when the average f_0F2 attains the minimum value for the whole day. Expressed as a percentage of the average value the amplitude of L2 variation at 0500 hours is 8.8 percent as compared to 5.0 percent at 1000 hours.

Concerning the seasonal variation of the lunar tide in f_0F2 at presunrise hours at Nhatrang the amplitude is 0.24 Mc/s (9.7 percent) during equinoxes, 0.18 Mc/s (7.7 percent) during summer and 0.15 Mc/s (6.9 percent) during winter months. The lunar tidal effects in f_0F2 at presunrise hours at Nhatrang are maximum during the equinoctial months. The seasonal variation in amplitude at Lindau are different, being 2.8 percent in winter and only 1.2 percent in equinoxes.

The variation of lunar tidal effects in f_0F2 with solar time at Nhatrang is compared with those at Huancayo and Canberra in Fig. 2. The early morning peak in the amplitude is clearly indicated at each of the three stations. The analyses of solar time variations in the lunar tide in f_0F2 at a few other stations viz. Christmas Island, Palmyra and Panama also indicate similar large amplitudes in the early morning hours. Fuller details of these analyses will be published later.

There are some other pre-sunrise phenomena in the ionosphere at low latitudes which may have some relationship with the lunar tide in f_0F2. Bhargava (1952) has reported cessation of ionospheric echoes during the predawn period at Kodaikanal. Skinner et al. (1954) reported a peak in the occurrence of ledges in the F2-layer during the time of layer sunrise at Ibadan. Similar pre-sunrise splittings and other phenomena in the F2-region in temperate latitudes have been also reported (Bandyopadhyay, 1959; Rastogi, 1960). A sharp peak in the height of maximum ionisation (h_mF2) and semi thickness (y_mF2) of the F2-layer has been observed at presunrise hours at Ahmedabad (Sheriff, 1956; Shirke, 1963).

Excerpt

RASTOGI, R. G., and S. Sanatani. Longitudinal effect in the equatorial F2-region of the ionosphere. J. Atmos. Terrest. Phys. 25, 739-742 (1963).

Soon after the installation of ionospheric observatory at Huancayo it was found that the daily variation of f_0F2 there showed a peak in the morning and again in the afternoon with a valley near noon, a phenomenon known as noon bite-out effect (Berkner and Wells, 1934). Similar characteristics of f_0F2 were found at other equatorial stations viz., Ibadan Tiruchy, Leyte, Palau Is. (Maeda, 1955), and is confined to latitude within about 10° from the magnetic equator (Rastogi, 1960a, b).

Maeda (1959) showed that the relative magnitude of the two peaks in f_0F2 at equatorial latitudes change systematically with the solar activity. The forenoon peak is smaller than the afternoon peak during years of low sunspot number but with increasing sunspot number the forenoon peak gets more and more predominant.

Rastogi (1959) showed that the diurnal variation of f_0F2 differs considerably at some stations having the same geomagnetic latitude, but the discrepancy disappears when the true magnetic latitude is taken into consideration. In this article we have discussed the longitudinal differences in the daily variation of f_0F2 at the equatorial stations having similar magnetic dip.

In Fig. 1 are plotted the yearly average daily variations of f_0F2 for different stages of solar activity at the equatorial stations Huancayo, Ibadan and Kodaikanal situated in the Western, Intermediate and Eastern zones respectively.

At Kodaikanal (dip 3.5°N) one finds a very distinct noon bite-out of f_0F2 in any of the years 1954 to 1962. During the years of low solar activity (1954, 1955, 1961 and 1962) the evening peak is higher than the morning one, whereas during the years of high solar activity (1956 to 1960) the morning peak is higher than the evening one. It is to be noted that there are two distinct peaks in the morning and evening hours with a valley around noon for Kodaikanal during any of the years of which the data are so far available.

At Huancayo (dip 2°N) even during the years of minimum solar activity, the evening peak is only slightly higher than the morning one. During the years of high solar activity the morning peak gets stronger, the noon bite-out and the evening peak become less significant so much so that during 1958 the daily variation of f_0F2 has only a single prominent peak in the morning hours with only a suggestion of slow decrease of f_0F2 in the afternoon hours.

At Ibadan, the features are intermediate between those at Huancayo and Kodaikanal. During the low sunspot years the evening peak is stronger than the morning one but the difference between the two peaks is not so large as that at Kodaikanal. During the high sunspot years although there

are both the morning and evening peaks the magnitude of noon bite-out is very small.
Excerpt

RASTOGI, R. G. A synoptic view of the lunar tide in the F_2 region of the ionosphere. J. Geophys. Res. 68, 1166-1168 (1963).

The analyses of lunar perturbations of the critical frequency of the F_2 layer of the ionosphere (f_0F_2) by various workers have clearly demonstrated a reversal of phase of lunar semi-diurnal variation, denoted $L_2(f_0F_2)$ variation, between equatorial and tropical latitudes [McNish and Gautier, 194?; Martyn, 1949; Kotadia and Ramanathan, 1956]. Rastogi [1961] showed that the phase of $L_2(f_0F_2)$ oscillation for the midday hours decreases from 04 lunar time at the magnetic equator to 10 lunar time at tropical latitudes, the change taking place at about 11° magnetic latitude. Further, the latitudinal variation of the amplitude shows a sharp maximum over the magnetic equator and somewhat wider maximums at 20° magnetic latitude. To understand the lunar perturbations in f_0F_2 at low latitudes and their interrelations with the development of the abnormal equatorial belt of the F_2 region, it was considered necessary to compute lunisolar coefficients of the lunar oscillations in f_0F_2 at a number of low-latitude stations, which would involve many analyses. In this note we attempt to give a qualitative general picture of the variation of the lunar tide in f_0F_2 at low latitudes.

The days of a month are divided into two groups one in which the phase of the moon μ lies between 3 ± 1 and 15 ± 1, here called μ_3 days, and another in which μ lies between 9 ± 1 and 21 ± 1, called μ_9 days. The maximum positive deviation in $L_2(f_0F_2)$ oscillation would occur on μ_3 days at the equatorial stations and on μ_9 days at tropical-latitude stations. As the mean phase difference between there two groups of days is 6 lunar hours, the difference between the average values of f_0F_2 at any station on the two groups of days would give a rough estimate of the amplitude of $L_2(f_0F_2)$ oscillation.

In Figure 1 are compared the mean diurnal variation of f_0F_2 on μ_9 and μ_3 days of the southern solstitial months at Huancayo (an equatorial station) at Panama (a northern tropical-latitude station) and at Buenos Aires (a southern tropical-latitude station), all in the same longitude zone. Since the ordinate scale of the diagram is logarithmic, the separation between the two curves for any hour indicates the proportional change in f_0F_2 due to lunar tide during that hour.

The value of f_0F_2 at Huancayo for any hour of the day is larger on μ_3 days than on μ_9 days, and the difference between the two curves is maximum during the noon hours, the period of well-known biteout in f_0F_2 at equatorial stations. At the tropical-latitude stations, Panama and Buenos Aires,

f_0F_2 is larger on μ_q than on μ_3 days for daytime hours, but the reverse for night time hours. The maximum difference between the two curves occurs at about 14 hours, the period when f_0F_2 attains its peak value of the day at these latitudes. Thus the maximum perturbations in f_0F_2 due to the moon occur at the equatorial stations at the time of midday biteout of f_0F_2, whereas in tropical latitudes they occur at the time of the afternoon peak of f_0F_2.

During the μ_3 days, the midday biteout of f_0F_2 is almost absent at Huancayo. Further, the midday values of f_0F_2 at Huancayo, Panama, and Buenos Aires are almost the same on μ_3 days, indicating the absence of equatorial dip in the longitudinal variation of f_0F_2. Thus the well-known equatorial anomalies of the F_2 region seem to be greatly reduced on μ_3 days.

The nighttime values of f_0F_2 are greater on μ_3 than on μ_9 days at both equatorial and tropical latitudes. Thus the reversal of phase of $L2(f_0F_2)$ oscillation in f_0F_2 between the equatorial and tropical latitudes occurs during the daytime hours only.

In Figure 2 is plotted the diurnal variation of mean f_0F_2 on μ_9 days minus that on μ_3 days (say Δf_0F_2) at a number of southern and northern hemisphere stations. This quantity would be positive or negative accordingly as the phase of $L_2(f_0F_2)$ oscillation is 9 or 3 lunar hours, respectively.

At Huancayo (magnetic latitude 1°N), f_0F_2 has the largest negative value of about 2.6 Mc/s at local noon. At other equatorial stations, Nhatrang, Baguio, and Singapore, at slightly higher latitudes, f_0F_2 has a minimum at noon, but its magnitude is less than that at Huancayo. This confirms the sharp maximum in the amplitude of midday $L_2(f_0F_2)$ oscillation over the magnetic equator.

At stations close to the subtropic peak of f_0F_2, Taipeh and Buenos Aires, f_0F_2 is positive for most of the daytime and attains the largest value (about 2.6 Mc/s) at 14 hours. During the nighttime f_0F_2 is slightly negative, indicating a smaller amplitude of lunar tide opposite in phase to the daytime tide. At still higher latitudes, Maui and Rarotonga, the magnitude of f_0F_2 becomes smaller, indicating smaller perturbations due to the moon. At still higher latitudes, Tokyo and Tananarive, the magnitude of lunar perturbations is further decreased. This confirms the existence of a broad maximum of $L_2(f_0F_2)$ oscillation at tropical latitudes for the afternoon hours of the day, when the solar diurnal variation of f_0F_2 also reaches its peak value.

To confirm the above conclusions, the coefficients of lunar semidiurnal oscillations in f_0F_2 were computed for each solar hour of the day at Okinawa and Nhatrang. The results are plotted in Figure 3. Referring to the plot for Okinawa, we find that the amplitudes of $L_2(f_0F_2)$ oscillation are much larger for the daytime than for the nighttime hours, being maximum at 13-14 hours LST. The phases for the daytime hours are opposite those

for the nighttime hours. At Nhatrang, the phases of $L_2(f_0F_2)$ oscillation for most of the daytime or nighttime hours lie between 00 and 03 lunar hour. There are two maximums of the amplitude occurring at 11 and 23 hours LST, the daytime maximum being the major one. A secondary maximum in the amplitude is indicated by the large negative values of f_0F_2 during the night at Baguio, Nhatrang, and Singapore (Figure 2). The coefficients of lunar variation in f_0F_2 at Ibadan given by Brown [1956] also indicate very large amplitudes for the midday as well as the midnight hours.

It is concluded that the lunar perturbations in f_0F_2 at low latitudes are closely associated with the diurnal development of the anomalous equatorial belt of the F_2 region. The large amplitudes of lunar tide in f_0F_2 at tropical latitudes are associated with processes that are responsible for higher values of f_0F_2 at these latitudes during the afternoon hours. Excerpt

RASTOGI, R. G. Lunar tidal variations in the equatorial electrojet current. J. Geophys. Res. 68, 2445-2451 (1963).

The lunar semidiurnal variations in the solar diurnal range of the horizontal component of the earth's magnetic field H are computed for the equatorial stations that were operating in Peru during the IGY and IGC. The amplitude is found to be greatly enhanced on either side of the magnetic equator within magnetic dip of about ±10°. The narrow regions of enhanced lunar tidal effect and solar diurnal variation in H are similar to each other, suggesting that lunar semidiurnal tides affect the same region as that which contains the well-known solar diurnal equatorial electrojet. The lunar effects in South America are found to be maximum during the southern solstice at stations within the zone of the equatorial electrojet, but during the equinoxes at stations in middle latitudes.
A

RASTOGI, R. G. Seasonal variation of the lunar tidal effects in the F_2 layer of the ionosphere over Indian stations. Proc. Indian Acad. Sci. 58A, 38-48 (1963).

Computation of the lunar semidiurnal oscillations in the midday values of the critical frequency (f_0F_2) and of the height of maximum electron density (h_pF_2) on the F_2 layer. The computation was based on data from all Indian ionospheric stations, and was made separately for each season of the year. The amplitude of oscillation in f_0F_2 is found to be larger in winter than in summer at each of the stations. There is a reversal in the phase of the oscillation in f_0F_2 between the equatorial and tropical latitudes; this is most evident in the winter months and is almost absent in summer. The annual average oscillation f_0F_2 is in

agreement with that found by Rastogi. The phase has a large seasonal variation of about 180° at an equatorial or a tropical latitude station. The phase and amplitude of the lunar tide in h_pF_2 do not vary significantly with latitude or season.
IAA

RATCLIFFE, J. A., and E. L. C. White. The effect of the earth's magnetic field on the propagation of short wireless waves. Phil. Mag. 16, 125-144 (1933).

It has often been suggested that when wireless waves are transmitted through the ionosphere their behaviour will be influenced to a very large extent by the presence of the earth's magnetic field. A complete theory of the propagation of an electromagnetic wave through an ionized medium in the presence of a steady magnetic field has been worked out. This magneto-ionic theory shows that, for a given ionization density and a given direction of the wave-normal relative to the magnetic field, two waves with characteristic polarizations and velocities may be propagated. As the characteristic polarizations and velocities depend both on the ionic density and on the direction of the wave-normal, it is clear that grave difficulties attend a theoretical consideration of the general case in which a wave is incident on a medium of changing ionization density in a direction inclined to the ionic gradient in the medium. A considerable simplification results, however, if we restrict ourselves to the case where the wave is incident on the medium along the direction of the ionic gradient, for in this case the wave-normal remains always along the same direction, and hence makes a constant angle with the magnetic field. These conditions are fulfilled when waves are received after being returned at vertical incidence by the ionosphere in which the ionization gradient is vertical, and by observing such vertically reflected waves it is possible to make an experimental test of some of the consequences of the magneto-ionic theory. It is the purpose of this paper to describe such an experimental test, and to discuss the bearing of the results obtained on our knowledge of the electrical structure of the upper atmosphere.
Excerpt

RATCLIFFE, J. A. Diffraction from the ionosphere and the fading of radio waves. Nature 162, 9-11 (1948).

A theory of fading is outlined which regards a "single" reflected wave as the sum of contributions from a large number of scattering centers in the

reflecting region, moving with velocities distributed according to a Gaussian law. The resultant signal is found to be analogous to that produced when random noise is passed through a filter with a specified band-pass characteristic and the results of an analysis of this case are applied to the present problem. It is shown that the observed fading characteristics of radio waves on various frequencies from 4 Mc to 16 kc are in accord with the theory, the rms values of the scattering center velocity being of the same order of magnitude in each case. The theory accounts for the observed fact that the rate of fading is roughly proportional to the frequency of the wave and the distance of the transmitter.
N

RATCLIFFE, J. A. A quick method for analysing ionospheric records.
J. Geophys. Res. 56, 463-485 (1951).

A method is described by which routine (h' - f) records can be analysed quickly to give information about the vertical distribution of electron density in the ionosphere. The method is approximate but is simple and quick to use, and is therefore convenient for making analyses of the type required for testing theories of the ionosphere. It consists in assuming, after Appleton, that the electron distribution is parabolic and then in constructing a series of curves, similar to those of Booker and Seaton, on a transparent scale, in such a way that they can be matched directly to the photographic records. The important parameters can then be read directly from the scale. Retardation in the F1 layer can be allowed for when the F2 layer is being analysed. Scales based on other electron distributions are also described and are useful in the analysis of unusual records of the type sometimes encountered at Huancayo. An account is given of the calculation of the total number of electrons in a unit column of the F2 layer below the level of the maximum. The calculations are made on the assumption that the earth's magnetic field is zero, and the effect of removing this limitation is discussed.
A

RATCLIFFE, J. A. Some regularities in the F2 region of the ionosphere.
J. Geophys. Res. 56, 487-507 (1951).

Analyzed (h'-f) records from Watheroo, Huancayo and College to find the integrated electron concentration by an approximate method, accurate to perhaps 25 percent. Investigated two quiet days a month in a year of sunspot maximum and a year of sunspot minimum. A close relation was found between the integrated F2-layer density, and the solar zenith angle, even though the same is not true of the maximum electron density. At Huancayo, during sunspot minimum, notes a reduction in total ionization associated with a spur rising to great heights from the F2-trace. Finds

a relation between the thickness and height of maximum density of the F-layer. Points out that similar studies of the F-layer have been made in the past without noting the regularities in the behavior of the maximum ionization content here described; further studies are suggested.
M

RATCLIFFE, J. A., E. R. Schmerling, C. S. G. K. Setty, and J. O. Thomas. Rates of production and loss of electrons in F region of ionosphere. Phil. Trans. Roy. Soc. London, Ser. A 248, 621-642 (1956).

Prior work showed it possible to deduce electron distributions in F layer appropriate to average magnetically quiet day in any one month, (data being given for Slough, Huancayo and Watheroo for different times of day, seasons and solar epochs); use these distributions as experimental facts from which rates of production and loss of electrons are deduced.
EI

RATCLIFFE, J. A. The Magneto-Ionic Theory and its Applications to the Ionosphere. (Cambridge University Press, Cambridge, England, 1959).

This book deals with the theory of electro-magnetic waves passing through a gas of neutral molecules in which is embedded a statistically homogeneous mixture of free electrons and neutralising heavy positive ions, in the presence of an imposed uniform magnetic field. A medium of that kind will be called a magneto-ionic medium and the theory will be called the magneto-ionic theory. It has been mainly applied to problems of radio-wave propagation through the ionosphere.

Although the ionosphere is not, in fact, a homogeneous medium, and a full discussion of the propagation of waves through it requires a full-wave theory of considerable complexity, it is often sufficiently accurate to suppose that the wave behaves, at each level, as though it were propagated in a homogeneous medium. Chapter 17 contains an elementary discussion of the conditions under which this approximation can be made. The rest of the book is concerned only with propagation through a homogeneous magneto-ionic medium and with those problems of radio-wave propagation through the terrestrial ionosphere which can be solved with the help of this theory.

Although much of the book is based on published papers, referred to in the Bibliography, substantial parts of it have not previously been published. They have, in consequence, not been submitted to public criticism as published papers would have been, and the reader is warned to accept them with caution. The sections 3.5, 3.6, 3.7, 3.8, 5.2, 5.3, 5.4, and Chapters 9, 10 and 14 are of this nature.
Excerpt

RATCLIFFE, J. A. Radio research 1962. Great Britain Department of Scientific and Industrial Research - Radio Research Board, (Jan 1963).

Radio research is reported in the following areas: (1) the lowest part of the ionosphere, (2) above the F layer, (3) antennas or small probes on space vehicles in the ionosphere, (4) long-distance ionospheric propagation, (5) cosmic rays, (6) ionospheric irregularities and movements, (7) the equatorial anomaly in the ionosphere, (8) the location of radio noise sources, and (9) development of a new ionosonde.
Source unknown.

RATCLIFFE, J. A. Field aligned irregularities. Review by Chairman, Commission III, 14th General Assembly, URSI, Tokyo, 10 Sept. 1963. National Academy Science Publication 1183, 267.

The "equatorial anomaly," well-known in the sub-peak F-layer, has been shown to extend for a considerable distance above the peak. At the greater heights it seems to follow lines of force of the terrestrial magnetic field, but at the sub-peak heights the characteristics are not field-aligned.

Other less-well marked "ledges" or "irregularites" in the electron distributions are also found to be field-aligned, and attempts are being made to identify the corresponding field lines with those on which exospheric particles are known to be trapped. These tentative results must still be accepted with caution.
Excerpt

RATCLIFFE, J. A. Ionosphere storms. Revised by Chairman, Commission III, 14th General Assembly, URSI, Tokyo, 10 Sept. 1963. National Academy of Science Publication 1183, 267.

Since there is no adequate theory to account for the observed behaviour of the sub-peak F-layer during ionosphere storms it would be of great value if we could know in detail what happens on the topside at these times. Unfortunately results from the topside sounder are still few and the main evidence comes from estimates of the total electron content between the ground and "beacon" satellites, or between the ground and the moon, deduced from observations of Faraday rotation or Doppler shift. These seem to indicate, fairly clearly, that when the sub-peak electron content decreases during a storm, the content above the peak also decreases. Observations of whistlers indicate that there is a similar decrease in the electron density even at distances of one or two earth radii.
Excerpt

RATCLIFFE, J. A. Theory of the F-layer. Review by Chairman, Commission III, 14th General Assembly, Tokyo, 10 Sep. 1963. National Academy Science Publication 1183, 268.

It is now generally believed that the F-layer ionisation is produced by solar ultra-violet radiation, that it disappears by a series of complicated processes involving charge-exchange reactions and that it is re-distributed by processes of diffusion. Investigations of the details of this mechanism have involved observations of the ultra-violet flux made from rockets and theories of the charge-exchange reactions. There are at present divergent views about the magnitudes of the quantities involved.

Attempts are being made to incorporate the new knowledge about the temperature variations of the neutral atmosphere (see section 4.2c) into theories of the F-layer, but at present the matter is not clear. There is also considerable doubt about the causes of the heating; ultra-violet radiation, the solar stream of particles, Joule heating, and (at times of storm) hydromagnetic waves, are all being considered.

The sideways diffusion of electrons along magnetic lines of force might cause the well-known "equatorial anomaly" in N_mF_2, and two independent attempts have been made to calculate its effect. Again there is disagreement, one group of workers consider that diffusion alone does cause the anomaly, the other that it does not.

In attempts to explain some of the anomalies of the F-layer, and in particular some of the field-aligned ones, suggestions have repeatedly been made that charged particles incident from outside might be responsible for some of the ionisation. It is however, difficult to see how they could produce ionisation at F-layer height, and so far there has been no detailed discussion of the problem.
Excerpt

RAWER, K. The effect of the magnetic equator on sporadic E ionization. Compt. Rend. 237, 1102-1104 (1953). (In French.)

E_s data from equatorial stations have been studied. Analysis shows that the marked maximum in E_s ionization at the magnetic equator, first reported by Matsushita preceding abstract exists only during the day and only for the ionized clouds characteristic of that layer. The effect is not found for that part of the E_s layer represented in the published data by fbE_s.
PA

RAWER, K. Irregularity and regularity of the sporadic E-layer. Geofis. Pura e Appl. 32, 170-224 (1955). (In German.)

From station observations much information on top-frequency fEs, less on blanketing frequency fbEs is obtained. The results may be interpreted in statistical terms. Time- and distance-correlation functions are established. Daily, seasonal and geographic regularities are discussed. A sharp maximum exists at the magnetic equator but only for the top-frequency. No well defined influence of the solar cycle has been found, only a very weak one of lunar tides. Apart from the routine evaluation observations of the variation of the reflection coefficient with frequency have been made. In temperate latitudes in about 1/3 of all cases there is no partial reflection; in the other cases local variations of electron concentration up to 1:2 are found, higher values are rare. At low latitudes the variation may be more important. This is found by a qualitative classification of ionograms of different stations. Such classification has been made for transparency, scatter, angle of incidence and layer development. Diffuse echoes exist often near the magnetic equator. Es is always vertically sounded at temperate latitudes. In most cases the ionization originates as a thin layer of constant altitude. Transitory phenomena coming downwards are responsible for "E2s" in daytime. It appears that a cumulo-cirrus-cloud layer is a good model for Es-ionization. An atmospheric ionization process using stored energy from dissociation or ion existence seems to be most probable.
PA

RAWER, K. Study of the transparency of the ionospheric layer called sporadic-E. Compt. Rend. 250, 1517-1519 (1960). (In French.)

An index called the "degree of occultation" of sporadic-E clouds is defined. Records have been examined from many observatories throughout the world. In temperate latitudes, the degree of occultation is high by day but low at night. For stations in a zone centred on the geomagnetic equator, the layer is found to be very transparent but more so at night than during the day. In the auroral zone, Es is rarely observed by day but at night, the median value of the degree of occultation is greater than at temperate latitudes.
PA

REBER, G. Spread F over Hawaii. J. Geophys. Res. 59, 257-265 (1954).

The random variations of intensity of signals from point sources caused by the ionosphere greatly affect studies of cosmic static. One cause of these fluctuations is the condition known as spread F, which indicates the presence of diffuse and irregular echoes from the F-region of the ionosphere. Analyses of spread F over Hawaii were completed for the period 1944-1953. The diurnal and seasonal properties are discussed, and a conclusion is reached regarding latitude and longitude effects. Some properties of scintillations at decameter waves are described.

A

REBER, G. World-wide spread F. J. Geophys. Res. 61, 157-164 (1956).

Data over the ascending and descending parts of the recent sunspot-cycle from widely distributed ionosphere stations have been utilized to trace the geographic features and nature of the spread-F equator in low latitudes. Indications are that the spread-F equator is nearly a great circle, approximately parallel to the geomagnetic equator, but swinging, during an 11-year period, through an angle of plus and minus 25° of latitude, about an axis through Japan and Argentina. The two fundamental types of spread F (polar and equatorial) and forked F are discussed.

A

REDDY, C. A., and B. Ramachandra Rao. The observed polarisation of high frequency radio waves at a low latitude station. J. Atmos. Terrest. Phys. 25, 13-22 (1963).

Systematic polarisation measurements on vertical incidence pulsed signals in the 2-4.6 Mc/s range have shown that the observed polarisation is essentially the same as that predicted by the magneto-ionic theory. The small discrepancies observed are explained as arising due to the contamination, on many occasions, of the apparently pure echo under observation by a weak component undetectable on the monitoring A'scope.

A

REDDY, C. A. The structure of E_s at a low latitude station as deduced from polarization observations. J. Atmos. Terrest. Phys. 25, 387-391 (1963).

The probable structures for different types of sporadic-E are discussed in the light of the measured polarizations of E_s-echoes. The observed

polarizations clearly suggest a "thin layer" structure with a sharp gradient for the semi-transparent type of E_s which is of most frequent occurrence at this low latitude station (Waltair).
A

REMMLER, O. D. Bibliography on direction finding and related ionospheric propagation topics 1955-1961. NBS. Tech. Note 127, National Bureau of Standards, Boulder, Colo. (Oct. 1962).

This bibliography is an outgrowth of a conference held at the University of California at Los Angeles in June 1960 to discuss the aspects of long-range high-frequency radio propagation that affect radio location and direction finding, and the related problems of measurement and analysis. A group of the papers presented at the conference was published in the Radio Propagation Section (Section D) of the Journal of Research of the National Bureau of Standards, May-June issue, 1961. In connection with the conference the Numerical Analysis Research Staff of UCLA prepared a bibliography of published work on the conference subject covering the period 1955-1959. For this Technical Note the UCLA bibliography has been edited and extended to include some papers published in 1960 and the first half of 1961. This compilation, though by no means exhaustive, includes over 850 titles on direction finding and related topics ranging from instrumental details through observations and data analysis to theories of propagation.
A

RENAU, J. A study of ionospheric spread echoes. Research Rept. EE-442, Cornell University, Ithaca, N. Y. (1959).

In this study we are concerned mainly with spread echoes from the F region, although a chapter has been devoted to a particular type of spread echoes from the E region.

In Chapter I the types of spread echoes most frequently observed are illustrated and described. A historical review of the scatter echoes is presented and a short summary of the problems to be considered is given.

The work described in Chapter II is an outline of Booker's theory of scattering by nonisotropic irregularities. This is slightly modified to accommodate data accumulated since it was published. The material in Chapter II, therefore, is not original, but is included for use in subsequent chapters.

We consider a particular type of spread echoes, referred to as sporadic echoes from the E region in Chapter III. It is shown that the suggested mechanism is an alternative to the mechanism suggested by Whale, and the consequences of our model lead to an explanation of the observed variations of cut-off frequency of the nonblanketing type of sporadic E with dip. Sporadic echoes from the F region are also considered.

In Chapter IV we deal with Eckersley's suggested hypothesis (1937) and show that the theoretically predicted ionograms explain a small class of spread echoes, but that, in general, the model cannot bring about the structural form of the type of spreads observed frequently in the northern stations.

In Chapter V, we make use of a model where aspect sensitivity is incorporated as a principal feature for the explanation of two types of spread F. It is shown that the predicted ionograms have no observed counterpart in the middle latitudes. In the equatorial regions, the predicted ionograms correspond to what is observed and the theory restricts the backscattered echoes to east-west directions. However, without using aspect sensitivity, one can also explain frequently observed equatorial spread echoes on the basis of backscattered echoes from all directions. In the northern regions the results of Chapter V are similar to a particular case of the results of Chapter IV.

Chapter VI is devoted to a morphological study of spread echoes. It is shown that types of spread echoes commonly observed at the northern stations, consist of superposition of overhead and oblique specular reflections as reported by workers in the field. Moreover, the same type of spread can be caused by the bifurcation of the F layer. The diurnal and seasonal variation of spread F for several stations is shown.
Excerpt

RENAU, J. A theory of spread F based on a scattering-screen model. J. Geophys. Res. 64, 971-977 (1959).

To shed some light on the phenomenon of spread F, a thin scattering screen is postulated above the E region. The virtual height which is associated with a pulse radiated from the sounder, forward scattered by the screen and then reflected back to the sounder via the F region, is calculated.

For frequencies appreciably larger than the penetration frequency, the minimum virtual height versus the operating frequency, on a linear scale, is a straight line, the slope of which depends on the height of the screen.

As the height of the screen increases, the slope decreases. When the scattering screen is assumed at the level of reflection, the slope of the line coincides with the tangent from the origin to the regular vertical-incidence trace.

Experimental ionograms are presented that fit with the suggested mechanism.
A

RENAU, J. Theory of spread F based on aspect-sensitive backscatter echoes. J. Geophys. Res. 65, 2269-2277 (1960).

To explain spread echoes from the F region the concept of aspect sensitivity was incorporated in our derivations of h'f curves using the assumption that the magnetoionic components can be treated separately. The shape of the h'f curves, as well as the extent of range and frequency spreading, was deduced for ionospheric stations located at various magnetic latitudes. The requirements of aspect sensitivity restrict the solid angle containing the echo rays to a wedge with its apex line running east-west through the transmitter location and with its angle determined by the dip angle. At the magnetic north the wedge opens flat, and at the magnetic equator the wedge degenerates into an east-west flat fan. The model does not lead to an explanation of a large class of observed spread F in the northern and middle latitudes. At the magnetic equator, however, the model is potentially capable of clarifying the observed spread F of a type shown in this paper.
A

RENAU, J. A study of observed spread F. J. Geophys. Res. 65, 3219-3240 (1960).

The main types of spread F have been illustrated; and in order to facilitate their study they have been categorized. Thereafter, our effort is concentrated in studying the morphology of a particular type of spread F observed at various magnetic and geographic latitudes (northern hemisphere). The total number of ionograms scanned during these studies amounts to about a hundred thousand. The first of these studies shows that the spread F type B (sharp inner and outer frequency edge) may be due either to the bifurcation of the layers or to large horizontal patches of ionization with varying degrees of electron density and tilted in a manner to reflect specularly, with scattered echoes superimposed on the structures thus obtained. As for the amount of frequency spreading $f_s = f_{max} - f_{min}$, the spread seems to be magnetically controlled, having its maximum at the magnetic north, decreasing with decreasing magnetic latitude down to 40° N, and increasing again at the magnetic equator.
A

RENAU, J. Theory of overhead nonblanketing sporadic E. J. Geophys. Res. 66, 2121-2128 (July 1961).

A model is suggested for overhead nonblanketing sporadic E based upon scattering from a belt (1 or 2 km in thickness) of irregularities within a stratified E layer. Predicted h'f curves are compared with observed data and found to be in good agreement.
PA

RIEKER, J. Sunset and sunrise in the ionosphere: Effects on the propagation of long waves. J. Res. NBS 67D, 119-138 (1963).

The purpose of this study, which is based on photographic recordings showing the phase shift of two signals—i.e., GBR transmitted from Rugby (England) on 16 kilocycles per second and NBA transmitted from Balboa (Panama) on 18 kilocycles per second, both received at the Neuchatel Cantonal Observatory (Neuchatel, Switzerland), is twofold:

(1) To investigate the mode of propagation of the GBR and NBA signals.

(2) To study the relation between the time of sunrise, respectively sunset at various ionospheric reflection points and the times at which phase fluctuations appear on the recordings. The author then generalizes the notion of the times of sunrise, respectively sunset by introducing the closely related concept of the zenithal distance Z of the sun at the reflection points considered. Following results published in literature, reflection point altitudes were assumed to be about 70 kilometers during the day. Results were such that:

(a) For the GBR signal; only a one-hop mode is available, night reflection altitudes varying between 88 and 91 kilometers on individual recordings, angles of incidence ϕ on the ground between 7°36' and 10°25'.

(b) For the NBA signal; a five-hop mode is available, night reflection altitudes varying between 80 and 84 kilometers on individual recordings, angles of incidence ϕ on the ground between 0°27' and 1°14'.

(c) At sunrise, respectively, sunset, computed zenithal distances for one and the same reflection point at times identical with singularities appearing on successive recordings show a striking analogy.

(d) During one and the same sunrise or sunset, the zenithal distances computed successively for various reflection points and related to singularities read on a same recording present also a striking analogy.

(e) The time of onset of ionizing radiation at all night reflection points seems to be of major importance for both the propagations of the GBR and NBA signals. During sunset, the altitude of the day reflection point which

was stabilized at around 70 kilometers increases as soon as the zenithal distance of the sun exceeds 90°. At sunrise, on the other hand, the altitude of the reflection point stabilizes at around 70 kilometers, when the zenithal distances of the sun reach or go below 90°.

(f) In the case of the NBA signal a phase fluctuation already occurs at a zenithal distance of about 103°, especially at sunrise. At that moment, the distance between the reflection point and the layer formed by the ionizing radiations of the sun is about 100 kilometers.

(g) At sunrise, the curves showing the energy of the received signals display the following features:

For a one-hop mode (Rugby), a momentary strong absorption when the reflection point altitude reaches 82 kilometers; in the case of several ionospheric reflections (Balboa), a succession of absorption lines corresponding to the successive diminishing of the altitude of the ionosphere reflection points.

(h) At sunset, the interpretation of the energy is more delicate:

For a one-hop mode (Rugby), a momentary increase occurs in the energy of the signal before the night level of reflection is reached; in the case of a five-hop mode (Balboa), the interpretation of the absorption curve is difficult because five ionospheric reflection points change their altitude and the resulting phase fluctuations become entangled.

A

RISHBETH, H. and D. W. Barron. Equilibrium electron distributions in the ionospheric F2-layer. J. Atmos. Terrest. Phys. 18, 234-252, (1960).

In the F-region of the ionosphere, the electron density is controlled by the production of ionization by solar radiation, loss by recombination, and transport of ionization by electromagnetic drift movements and plasma diffusion. This paper is especially concerned with the factors which govern the F2-peak of electron density.

An electronic computer has been used to solve the relevant equations for conditions of equilibrium such as may be approached in the day-time F-region. From the numerous examples considered, it is deduced that the maximum electron density, and the height at which it occurs, are such that the magnitudes of the production, loss and diffusion processes are approximately equal. The modifications produced by vertical electromagnetic drifts are discussed.

Most of the work relates to the simple case of an isothermal atmosphere, but the conclusions derived are found to be substantially true for a few more general models which have been considered.

A

RISHBETH, H. Horizontal diffusion and the geomagnetic anomaly in the equatorial F region. Nature 193, 56 (1962).

Dr. Lyon concludes that, at the magnetic equator, the vertical distribution of electron density N takes the form $N \propto e^{-2z}$ above the F2 peak, the height z being measured in units of the scale height of the ionizable gas. This is in contrast to the situation at high latitudes where vertical diffusion is not hindered by Earth's magnetic field, and the ionization takes up a distribution resembling that of a gas, the molecular weight of which is half that of the positive ions (for example, ref. 1); that is, $N \propto e^{-1/2z}$.

Lyon's result is obtained by consideration of the continuity equation for N, which at equilibrium may be written:

$$q - \beta N + \{D\} = 0 \qquad \text{(A)}$$

Here, q and β represent the production-rate and loss-coefficient; and transport of ionization by processes other than diffusion is omitted. To a first order, ionization can only diffuse along the lines of magnetic force, in the direction of Lyon's co-ordinate x, and the diffusion term $\{D\}$ may be expressed in terms of this co-ordinate: see Lyon's equation (1). Lyon then assumes that $\partial^2 N/\partial x^2 = 0$ at the equator, where the dip angle I vanishes; and that at any height N is determined by the local values of the production, loss and diffusion parameters. His conclusion then follows from equation (5).

Now at great heights in the F region both q and β are so small that equation (A) reduces to $\{D\} = 0$. This is the condition for the ionization to be in diffusive equilibrium, and is incompatible with the assumption that $\partial^2 N/\partial x^2 = 0$.

The intention of this communication is to point out that the distribution of ionization in diffusive equilibrium along a line of force, N(x), must vary with altitude z in the same manner, $N \propto e^{-1/2z}$, at low latitudes as elsewhere. This is just the simple Boltzmann distribution for the partial pressure of ionization, and is independent of the geometry of the field which constrains diffusion.

Previous theoretical studies of an idealized F region controlled by production, loss and diffusion refer to higher magnetic latitudes, say, $I > 30°$. Solution of the equation (A) shows that in the lower part of the F region the vertical distribution of ionization. N(z), resembles the 'photochemical equilibrium' value $q(z)/\beta(z)$. The F2 peak occurs where diffusion and loss are of comparable importance. At any height z well above the peak, the form of N(z) does not depend on the local rates q(z) or $\beta(z)$, or even on the diffusion coefficient at this height; instead, the profile of N is of the form appropriate to diffusive equilibrium, proportional to $e^{-1/2z}$. In the actual F region, the photochemical processes are probably dominant below 300 km. and diffusion is dominant above 450 km.; these figures are approximate.

It is suggested that this qualitative description of an equilibrium layer is valid even in low latitudes in the following way. Consider a line of force which crosses the equator at a height greater than 450 km., at which diffusion is dominant. The distribution of ionization along the highest, central portion of this line of force does not primarily depend on the local values of q and β; instead, N(x) is adjusted by diffusion so that equation (A) is satisfied everywhere, and is then largely governed by the photochemical rates on the portions of the line of force which lie in the lower F region, below an altitude of 300 km. These portions are situated some distance north and south of the equator.

The foregoing discussion refers only to the distribution of ionization, N(x), along a line of force. It does not give the vertical distribution N(z) at a single latitude; in order to determine this, it is necessary to solve equation (A) for many separate lines of force and thus find the equilibrium distribution of ionization in both latitude and height. Nevertheless, there is no reason to believe that the vertical distribution of ionization in the upper F layer above the magnetic equator differs greatly from that at other latitudes.

I am indebted to Dr. Lyon for sending a copy of his communication in advance of publication.

Complete.

RISHBETH, H., A. J. Lyon, and M. Peart. Diffusion in the equatorial F layer. J. Geophys. Res. 68, 2559-2569 (1963).

The theoretical form of the ionospheric F layer near the magnetic equator is discussed for conditions of equilibrium. A digital computer is used to solve an equation which includes photoionization, loss, and the diffusion of ionization along geomagnetic field lines, thus enabling electron densities to be computed as a function of latitude and height. A small equatorial 'trough' is found in the peak electron density, but this is much smaller than the well-known Appleton anomaly of the actual F layer. Below the peak, the ionization is approximately in 'photochemical equilibrium'; the shape of the layer above the peak corresponds approximately to 'diffusive equilibrium.'

A

ROBERTS, W. T. Properties of the F2 region in the ionosphere. NASA, Marshall Space Flight Center, Huntsville, Ala. (15 April 1963).

Several aspects of the F_2 region of the ionosphere, based on the results of recent studies of the 1958 IGY data, are investigated. Contour maps reveal an unexpected pattern from approximately 20° north to 20° south of the geomagnetic equator, and special attention is given to this region.
STAR

RODAM, T. Improving inter-continental communications. Wireless World 50, 295-298 (1944).

Suggestions for operating a world-wide shortwave communications network, based on a "girdle" round the tropics, are given. A band width of 6 Mc/s may be assumed for this route (by suitable choice of frequencies in the different parts of the route), and about 1,500 telephony channels are practicable. It is suggested that these are grouped into blocks of 12 to link with existing carrier systems, and the various problems of allocating these blocks and transposing frequencies are discussed.
A

ROONEY, W. J. Lunar diurnal variation in earth-currents at Huancayo and Tucson. Terrest. Mag. Atmos. Elec. 43, 107-118 (1938).

No abstract.
PA

ROSS, W. J. The determination of ionospheric electron content from satellite Doppler measurements. 1. Method of analysis. J. Geophys. Res. 65, 2601-2606 (1960).

A procedure of determining the ionospheric electron content up to the height of an active satellite from Doppler data is developed. The equations

derived from first-order theory are discussed and corrected separately for earth curvature, large refraction, off-zenith orbit, vertical satellite motion, horizontal ionospheric variations, and the effects of the earth's magnetic field. The methods were developed initially for use with the harmonic radiations from satellite 1958δ_2 at frequencies of approximately 20 and 40 Mc/s, but may be adapted to other harmonic frequency ranges. The results obtained by applying this method to the experimental data from 1958δ_2 are presented in part 2.

ROSS, W. J. Investigation of high frequency propagation in the ionosphere using satellite transmissions. Quarterly Status Rept. 9, 15 July 1961 - 15 Oct. 1961, Contract AF 33(616)-6157, Ionosphere Research Laboratory, Pennsylvania State University, University Park, Pa. (1961). AD-271 192.

The use of satellite radio transmissions to study the regular and irregular properties of the ionosphere is discussed. Preliminary data are given on the presence of elongated inhomogeneities of about 500 kilometers height. The evaluation of electron content at midlatitude, and near the magnetic equator is described.
ASTIA

ROSS, W. J. and L. J. Blumle. The distribution of ionization about the magnetic equator. Proc. International Conference on the Ionosphere, London, July 1962, 84-87 (The Institute of Physics and the Physical Society, London 1963).

Measurements of the electron content of the ionosphere made at Huancayo, Peru, and State College, Pennsylvania, using satellite radio signals, are presented and discussed. The diurnal variations of electron content and of equivalent slab thickness near equinox of the two sites are compared with particular reference to the relative importance of vertical diffusion.
PA

ROSS, W. J. The diurnal and annual variation of equatorial ionospheric electron content. Paper presented to Commission III, URSI, Fall Meeting, Seattle, Washington, Dec. 1963.

Measurements of ionospheric electron content made at Huancayo, Peru, over a period of 14 months using satellite radio beacon transmissions are presented and discussed. Daytime values are found to follow almost linearly the day-to-day variations in 10 cm solar radio flux, implying an almost

linear dependence on ultraviolet ionizing radiation flux. A marked seasonal effect is noted in the normalized electron content data, with a 40 percent reduction at the June solstice relative to values at the equinoxes. A study is also made of the diurnal changes in the vertical electron density profile. The implications of these results on the relative roles of ion production, recombination and transport at the magnetic equator are discussed.
A

ROSTAD, A. Auroral phenomena and world-wide magnetic disturbances. Geofysiske Publ. 10, 1-10 (1935). (In Norwegian.)

After referring to two previous publications dealing with the southerly extension of the aurora and a linear relation established between the intensity of magnetic disturbances and the pole distance of the aurora for data from Potsdam the author discusses the difficulty of obtaining a definite value for the pole distance useful for the present investigation. The relation between the pole distance Θ , and the intensity of the magnetic disturbances P is then considered. Results from stations comparatively near the pole are not suitable as shown by curves drawn for Potsdam and Rude Skov (Denmark). On the other hand observations from equatorial stations may be used. The method of finding a value for P from the observations of five equatorial stations is given, and the values of P so found plotted in diagrams for days on which aurora occurred, the observations extending over a period of years. This enables a graph to be constructed giving the relation between P and Θ and another between P and the southward extension of the aurora. The latter has a greater curvature than the former. The results so found are discussed, and also the relation of to the alternation of the earth's magnetic field from causes remote from the earth.
PA

ROY, R. and J. K. D. Verma. Polarization of electromagnetic waves for vertical propagation in the ionosphere. J. Geophys. Res. 60, 457-482 (1955).

A theoretical study of the variation of the state of polarization of a vertically incident electromagnetic wave while in propagation in the

ionosphere has been made on the basis of an approximate solution of the wave equations obtained by Saha, Banerjee, and Guha. It has been shown that the major axes of the polarization ellipses of both the ordinary and the extraordinary waves would lie in the N-E quadrant in the northern hemisphere and in the N-W quadrant in the southern hemisphere. A new method has been outlined for the determination of the electron density and the collision frequency in the ionized layers from the value of the tilt-angle and the ratio of axes of the elliptic patterns.

An analysis of the characteristics of the experimentally observed polarization patterns indicates that in E layer the value of v is 1.7×10^6 per second. They further show that the polarization of the downcoming waves corresponds to their respective reflection levels, rather than a limiting region below the E layer.

SACHDEV, D. K. Study of the atmospheric radio noise at 27 and 100 kc/s at Delhi. J. Sci. Indus. Res. 17A, 262-270 (1958).

A preliminary report of the observations on v.l.f. atmospheric radio noise being carried out by the Radio Propagation Unit, National Physical Laboratory of India, New Delhi (28.5°N, 77°E), is presented. Measurements are currently made at two frequencies, namely 27 kc/s and 100 kc/s. Diurnal and seasonal variations indicate appreciable ionospheric attenuation during daytime, and a summer afternoon maximum, possibly associated with local thunderstorms. Noise intensity falls rapidly during the early morning hours, the "sunrise time" differing greatly from one day to another. The sunrise fall is sharper at 100 kc/s than at 27 kc/s. Long period (~ 2 hr) fading is observed on certain nights, and is believed to be associated with disturbed conditions in the ionosphere. Particular attention is given to the study of sudden enhancement of atmospherics (S.E.A.) for which the observations were initially undertaken. It is found that enhancement is observed at both frequencies at the time of a solar flare; the effect at 27 kc/s is normally larger and earlier than at 100 kc/s. However, there is no one-to-one correspondence between the S.E.A. and the solar flare. Further, cases have been observed when the S.E.A. at 100 kc/s is found to be larger than at 27 kc/s. From the present observations it is suggested that transition from enhancement to fadeout occurs somewhat beyond 100 kc/s.
EEA

SAHA, A. K. and S. Ray. Some feature of the E2 layer observed at the ionosphere field station, Haringhata, Calcutta. J. Atmos. Terrest. Phys. 7, 107-108 (1955).

The automatic ionospheric recorder normally shows a thick extensive E2 layer in daytime. It usually originates at F1 level at or after 13 h LMT and descents to merge with E1 layer.
N

SAHA, A. K., M. Karabin, and K. K. Mahajan. Ionospheric effects following distant nuclear detonations. J. Atmos. Terrest. Phys. 25, 212-218 (1963).

Preliminary results are given of observations made at Delhi of some ionospheric effects following the Russian nuclear detonations during August and September 1962.
JPL

S

SAHA, A. K., and K. K. Mahajan. D and F region effects on cosmic radio noise absorption following nuclear detonations. J. Atmos. Terrest. Phys. 26, 618-624 (1964).

In a previous communication from this laboratory (Saha et al., 1963) the nature of ionospheric effects observed at Delhi following the Russian nuclear detonations in the Novaya Zemlya area in 1962 were described. The effects of the detonations could be detected with various instruments that are in operation in this laboratory as a part of regular ionospheric studies. They include (a) atmospheric noise level measurements at 27 and 100 kc/s, (b) long wave field strength measurements at 164 kc/s (Radio Tashkent), (c) an ionosonde and (d) cosmic radio noise measurements at 22.4 Mc/s. Two types of effects were identified: one occurring in the D-region and the other in the F-region. The D-region effects could be distinguished in the enhancements of noise levels of atmospherics, as also on long wave field strength records. They occurred within two hours after detonation. The F-region effects could be noted in ionograms as enhancements in f_0F2 occurring somewhat later (up to five hours delay). Both D- and F-region effects could be noted in cosmic radio noise absorption. The D-region effects were coincident in time with the low frequency effects. F-region effects could be noted in enhanced absorption coinciding with the post-detonation f_0F2 increases and could be observed only when the enhanced f_0F2 was above a threshold value of 10 Mc/s. The D-region effects of nuclear detonation on cosmic radio noise absorption have been reported by many workers (for example, Matsushita, 1959; Basler et al., 1963). The F-region effects reported from this laboratory (Saha et al., 1963), being separated in time from the D-region effects, allow some unique opportunities to study F-layer contribution to cosmic radio noise absorption.

Figure 1(a) is an example of cosmic radio noise absorption effect coinciding with the low frequency effects. The f_0F2 value on the day (even with the post-detonation increase) was quite low (9.2 Mc/s). Figure 1(b) is a case where post-detonation increase in f_0F2 reached 14 Mc/s. The corresponding cosmic radio noise absorption effect can be noted. No low frequency effects were noted on this day. In Fig. 2 both D- and F-region effects can be noted. There are actually three absorption peaks, the first one corresponding, presumably, to the D-region effect and the two others correspond very well with the two f_0F2 peaks noted after detonation.

The various cosmic radio noise effects observed for the Novaya Zemlya explosions in 1962, are summarized in Table 1. The correspondence in time of the effects observed with the low frequency D-region effects and the f_0F2 increases can be distinguished from the delay times noted against them.

S

No solar flare events were reported in CRPL F-Series (Part B) during periods covered by the observed effects.*

Table 1. Summary of the detonation effects on cosmic radio noise at 22.4 Mc/s

				Delay Times				
		Reported					F-Layer effects	
		Time of Ex-	Estimated	L.F.	C.R.N.			f_0F2
S. No.	Date	plosion U.T.	Strength	t_1	t_1	t_2	t_2	Mc/s
	1962							
1.	Aug. 25	09 00 01	9 MT	40	20	N.E.	210	9.2
2.	Aug. 27	09 00 39	14 MT	130	140	220	210	10.6
3.	Sep. 15	08 02 02	15 MT	150	130	?	?	13.0
4.	Sep. 21	08 01 02	9 MT		25	100	90	12.0
5.	Sep. 27	08 03 04	32 MT	N.E.	N.E.	220	210	14.0
6.	Oct. 27	07 35 00	3 MT	30	30	N.E.	210	10.0
7.	Oct. 29	07 35 00	4 MT	65	N.E.	110	120	12.5
8.	Nov. 1	06 30 00	3 MT			130	120	12.0
9.	Dec. 24	10 44 09	8 MT		120	N.E.	210	5.0
10.	Dec. 24	11 12 09	19 MT		120	N.E.	210	4.0

t_1: delay time in minutes for D-region effects
t_2: delay time in minutes for F-region effects
Blank: No records or poor records
N.E.: No effect

It may be pointed that, whereas effects corresponding to the f_0F2 increase could always be observed when the f_0F2 value with post-detonation enhancement was above a threshold value, the D-region effect on cosmic radio noise absorption could not always be noted when effects were noted with the low frequency equipments. (Table 1 is a list of cases chosen for cosmic radio noise effects only, out of 21 detonation cases for which records are available.) This, together with the fact that no effect could be observed from an examination of f_{min} values (obtained with the ionosonde) would indicate that the D-region effects of the explosions were

*On November 1 and December 24, 1962 some class 1 flares were reported around the explosion times (at 0600-0730 hours U.T. on Nov. 1 and 1005-1330 hours U.T. on Dec. 24). However, there were no reports of SIDs.

somewhat localized to heights lower than the effective height for normal cosmic radio noise absorption.

Contribution of the F-layer to cosmic radio noise absorption is believed to be controlled by the ratio f_0F2/f alone, f being the recording frequency of cosmic radio noise (Mitra and Shain, 1953). The dependence of F-region contribution to absorption on f_0F2 for Delhi at 22.4 Mc/s was studied by Sarada and Mitra (1961) and was given in Fig. 10 in their paper. Using the relation obtained by them for daytime we have computed the expected additional F-layer contribution to absorption corresponding to the f_0F2 increases following detonations on the assumption that the absorption effect due to detonation occurs at the same level as the normal (F-region) absorption. In Fig. 3 it can be seen that this calculated excess absorption, although somewhat lower, is nonetheless of the same order as the excess absorption value obtained from riometer records following detonation.

It appears there is some threshold value for f_0F2, above which the absorption effect in cosmic radio noise occurs following a nuclear detonation. In Fig. 4 a few absorption cases are shown, the f_0F2 values corresponding to the absorption increases are also indicated in the figure. Peak to peak coincidence of absorption and f_0F2 could have been missed since ionograms were taken at half hour intervals only. It will be noted from Fig. 4 that the absorption effect due to the F-layer does not appear if f_0F2 is less than 10 Mc/s (see also Table 1) and that the effect progressively increases in magnitude with increase in f_0F2.
Excerpt

SAHA, M. N. and K. B. Mathur. <u>The propagation and the total reflection of electromagnetic waves in the ionosphere</u>. Indian J. Phys. <u>13</u>, 1-12 (1938).

Explain investigation into propagation of Bose. Consider reflection conditions resulting from zero group velocity, reflection conditions when absorption is not zero.
M

SALAMAN, R. K. Historical survey of fading at medium and high radio frequencies. NBS Tech. Note. 133, National Bureau of Standards, Boulder, Colo. (Jan. 1962).

This condensed historical survey contains information on many of the articles concerned with HF and MF ionospheric fading, which have appeared in the literature through 1960. The primary emphasis is on an oblique incidence propagation, although many articles pertaining to fading at vertical and near vertical incidence (incorporating winds experiments) are also included. No effort was made to include the fading and scintillation studies in the literature of radio astronomy and satellite propagation, where they pertain to determining the characteristics of the ionosphere, and not to MF and HF communication.

Information is available on the origin of fading, the approximate dependence of fading rate on distance and frequency, and the amplitude distributions for particular transmission paths. This information is, however, not sufficient either for a realistic estimate of the performance of communication systems or for signal design consistent with the medium statistics.

With respect to communication systems at MF and HF, information which is needed for analysis and design includes statistics on the amplitude distribution and the fade rate, depth, and duration. Such information should be obtained as a function of propagation mode, frequency relative to the predictable MUF, time, season, geographic location, and sunspot cycle.
A

SALPETER, E. E. Effect of the magnetic field in ionospheric backscatter. J. Geophys. Res. 66, 982-984 (1961).

Theoretical results have been derived recently Dougherty and Farley, 1960; Fejer, 1960; Salpeter, 1960] for the frequency spectrum of the return signal in radar backscatter from free electrons in the high ionosphere and exosphere, assuming perfect thermodynamic equilibrium. In these calculations the earth's magnetic field B was neglected and some effects due to this fie. ' are discussed in the present note.
Excerpt

SANDSTROM, A. E., and S. E. Forbush. Sudden decreases in cosmic-ray intensity at Huancayo, Peru, and at Uppsala, Sweden. J. Geophys. Res. 63, 876-878 (1958).

Fenton, Fenton, and Rose showed that from 1954 to 1957 the sea-level neutron intensity at geomagnetic latitudes 57°N and 83°N decreased about 22 percent. During the same period they found that the sea-level meson intensity at these same latitudes decreased about 5 percent. On the other hand, they found the ratio of the percentage decrease in neutron intensity changes at Ottawa, to that in meson intensity for several rapid decreases during 1957, varied from about 0.9 to 2.7. Since these ratios differed from the corresponding one (about 4.4) for the intensity changes from 1954 to 1957, this provided independent evidence supporting the conclusion of Forbush that the transient decreases are only superposed on the intensity variation with sunspot cycle, but are not in themselves the cause of it.

Figure 1 shows the changes from the value on "0" day, in daily means (GMT) of neutron intensity at Uppsala relative to those in ionization at Huancayo during eight rapid decreases and recoveries between September 1956 and December 1957. The "0" day was that on which the minimum daily mean occurred. From the slopes of the lines in Figure 1, the ratios in Table 1 were obtained. These ratios seem definitely to vary for different transient decreases (and recoveries). Also, it is significant that the ratio for the recovery appears never to be less than that for the decrease, indicating for some cases that the energy spectrum of excluded particles changes differently with time during the decrease than during the recovery.

In Table 1, the ratios for the sudden decrease, and recovery, for September 3, 1956, appear to be definitely greater than for any of the other cases. In September 1956, the neutron intensity at Ottawa was about 10 percent below that in 1954, while the average for 1957 was about 20 percent below that for 1954; the corresponding figures for ionization at Huancayo were, respectively, about one and three percent. This indicates that the ratios in Table 1 probably decrease toward the maximum of solar activity; this possibility was indicated by Fenton, et al. Such a change in these ratios would be expected, since with increasing solar activity there is an increase in the energy of primary particles excluded by the solar-cycle modulation mechanism. These excluded particles would thus account for the smaller ratio for transient decreases at Uppsala relative to Huancayo.

Finally, it should be pointed out that Fonger found that the ratios of the 27-day neutron intensity changes from July to October 1951 at Climax (geomagnetic latitude 48°N) were about five times those in ionization at Huancayo. At this time, the ionization at Huancayo was about 1.5 percent below the maximum in 1954. Thus, this ratio is in reasonable agreement with those in Table 1 for September 3, 1956, for a roughly similar level of intensity at Huancayo.

Excerpt

SARMA, N. V. G., and A. P. Mitra. Some aspects of the geomagnetic distortion of the F_2 region at equatorial latitudes. J. Sci. Indus. Res. 15B, 320-322 (1956).

A study of the diurnal variation in the critical frequency of F2 layer at equatorial stations such as Madras Ibadan, Huancayo, Leyete, Kodaikanal and Tiruchirapalli (all 7-13°N or S and 0 to 10°N or S geomagnetic lat.), shows that the noon bite-out and the equatorial geomagnetic anomaly are a result of a strong semi-diurnal vertical drift (downward flow of ionization at midday). Graphs show variations of P1 and P2 with magnetic dip for 1954. Variations of P1/P2 variations, sunspot number for different equatorial stations, variations of critical sunspot number with magnetic dip and variation of P1 and P2 with sunspot number for Tiruchirapalli (10°50'N, 78°50'E) $(f_1 - f_2)/f_2 = P_1$ and $(f_3 - f_2)/f_2 = P_2$ where f1, f2 and f3 are forenoon maximum, noon minimum and afternoon maximum critical frequencies of F2 layer.
MGA

SATO, T. On the effect of the earth's magnetic field on the virtual height of the ionosphere. J. Geomag. Geoelect. 3, 90-99 (Dec. 1951).

The virtual height is calculated of the reflection point of a radiowave incident in the ionosphere at a frequency of $0{\cdot}834f_c$, where f_c is the critical frequency of the ionosphere, in the presence of the earth's magnetic field. The magnitude of the retardation of the wave resulting from the transmission in the lower ionized layer is also calculated. The inclination of the magnetic field vector is taken as 0°, 30° and 90°. It is found that the virtual height of the reflection point of the wave at a frequency of $0{\cdot}834f_c$, which is equal to the actual height of the ionosphere in the one of no magnetic field, does not indicate the actual height in the presence of the earth's magnetic field, and the value of the retardation depends on y, which in the ratio of the gyro-frequency to the wave frequency, and on f_1/f_2. where f_1 and f_2 are the critical frequency of the lower and upper ionized layers respectively. Further, it is also found that the effect of the earth's magnetic field on both virtual height and retardation is maximum, when the inclination of the earth's magnetic field vector is 0°, that is, on the magnetic equator; and minimum when the inclination is 90°, that is, on the magnetic pole.
PA

SATO, T. Disturbances in the ionospheric F2 region associated with geomagnetic storms. 1. Equatorial Zone. J. Geomag. Geoelect. 8, 129-135 (1956).

Explanation of the ionospheric F2 disturbances on the equatorial zone as the effect of the vertical drift of the electrons caused by the electric field associated with the disturbance-daily variation of the earth's magnetic field. The geomagnetic and the ionospheric data are those of Huancayo on the magnetic equator. The disturbed variations are calculated for the individual ionospheric disturbances. The results show that the calculated variations of the disturbances agree well with the observed ionospheric data, both in the magnitudes and in the characteristics of the variations.
PA

SATO, T. Disturbances in the ionospheric F2 region associated with geomagnetic storms. 2. Middle latitudes. J. Geomag. Geoelect. 9, 1-22 (1957).

In Pt. 2, it is shown that in middle latitudes the variations of f_0F2 on storm days are of two types: negative and positive disturbances; the former being the same as the representative variation in high latitudes while the latter is analogous to the variation in low latitudes (including the equator). On the other hand, the variations of h'F2 are analogous to those in high and low latitudes, regardless of the seasons. The results of the calculations for individual states show that two types of disturbances in middle latitudes seem to be explained as an effect of the vertical drift of the electron, though the coincidence between the observed and calculated for the positive type is not sufficient. From the above results, together with the results previously obtained for the equatorial zone, it is found that the occurrence of the positive or negative disturbances is ascribed to the conditions that the phase of the drift velocity of the electron on the quiet day is the same as that of the drift velocity on the disturbed day (negative), or the phase of the former differs from that of the latter by about 180° (positive). It is also found that the seasonal and latitudinal variations of the F2 disturbances are due to the existence of the Sq dynamo current in the ionosphere.
MGA

SATO, T. Disturbances in the F1 and E regions of the ionosphere associated with geomagnetic storms. J. Geomag. Geoelect. 9, 57-60 (1957).

It was pointed out by Berkner and Seaton [1] that the critical frequencies (f_0F1, f_0E) and the virtual heights ((h'F1, h'E) of the F1 and E regions begin to vary at the same time when those in the F2 region do in the storm time. However, up to date the details of the variations in the F1 and E regions have been overlooked. One of the reasons may be that the variations

in those regions at night cannot be known and the other that the deviations from the normal value are small compared with those in the F2 region. The purpose of this report is to show statistically the characteristics of the deviations in those regions.

SATO, T. Disturbances in the ionospheric F2 region associated with geomagnetic storms. 3. Auroral latitudes. J. Geomag. Geoelect. 9, 94-106 (1957).

In Pt. 3, a study is made of F2 disturbances in auroral latitudes. The process of the study is analogous to that in middle and lower latitudes. The results show that F2 disturbances in the auroral latitudes, as well as those in lower ones, are ascribed to the effect of the vertical drift of electrons caused by electric field deduced from the geomagnetic disturbance-daily variation.
MGA

SATYAM, M. Short term amplitude probability distribution of impulsive atmospheric radio noise. J. Sci. Indus. Res. 21D, 221-227 (July 1962).

SATYAM, M. Long term amplitude probability distribution of atmospheric noise. J. Sci. Indus. Res. 21D, 251-260 (Aug. 1962).

SATYAM, M. Hourly variation of seasonal atmospheric noise levels. J. Sci. Indus. Res. 21D, 260-264 (Aug. 1962).

SATYANARAYANA, R., and S. R. Khastgir. Polarization of down-coming wireless waves of medium wavelengths. J. Sci. Indus. Res. 11B, 211-215 (1952).

Investigations at selected radio station in India showed that: 1) only ordinary waves were received, 2) the polarization was lefthanded and elliptical, at times turning into a straight line or a circle and 3) the ratio of normal and abnormal component and the phase difference between these components varied randomly with time.
N

SATYANARAYANA, R., and D. Rai. Interference of polarized components of the radio wave in the ionosphere. J. Sci. Indus. Res. 13A, 66-71 (1954).

It was shown by Appleton and Beynon that the magneto-ionic components of the radio wave in the ionosphere caused by the earth's magnetic field produced interference and yielded periodic fading patterns during the evening hours, when there was a continuous decrease in the electron density of the ionosphere. The initial "slow" periodic fading observed by them on 9.53 Mc./s. was considered as due to the interference of the lower-trajectory ordinary and extraordinary waves. The rapid periodicity observed subsequently started only when the upper-trajectory waves (often called the "Pedersen" rays) were received at the same time.

SATYANARAYANA, R., K. Bakhru, and S. R. Khastgir. Polarization of the echoes from the Es and F regions. J. Sci. Indus. Res. 15B, 331-329 (1956).

The polarization of the echoes from the E_s and F regions, at night and in the early morning hours, has been studied using pulses of waves of frequency 3 Mc/s., at vertical incidence, and employing a polarized aerial system connected to a sensitive receiver. The oscillograms taken with the unpolarized receiver and the polarized receiving system showed, besides the sporadic E echo, which was of rapidly varying intensity and the magnetically split F echoes in different orders of reflection, a new type of reflection from the E_s and F regions with an equivalent height, 2F-E. As this new type was found to be left-handed, it has been called the M_O echo, as distinguished from the right-handed extraordinary M echo. Usually this echo was observed simultaneously with the sporadic E echo which was predominantly left-handed in polarization. A possible mechanism has been put forward to explain the occurrence of the left-handed M echo and the observed E_s echo with a pronounced left-handed polarization, and a detailed discussion presented on the intensity and polarization of the observed F echoes.
A

SATYANARAYANA, R., K. Bakhru, and S. R. Khastgir. Triple-splitting of the F-echoes. J. Atmos. Terrest. Phys. 13, 201-204 (1959).

An account is given of the polarization studies made on the triple F-echoes, obtained by employing pulses of waves of frequency, 3 Mc/s. at vertical incidence. The polarization studies revealed that the first component after the ground-pulse was the normal extraordinary component having a right-handed sense of rotation, the second component was the normal

ordinary component having a left-handed sense of rotation and the third component was the Z-component having a left-handed sense of rotation.

In addition to the coupling process suggested by Eckersley and Rydbeck between the ordinary and extraordinary waves, and operative only in high geomagnetic latitudes, the partial reflection and transmission at the level of ionospheric reflection for the ordinary component have been considered as a plausible process for getting the Z-component. Since the coupling process is not likely to produce a detectable Z-component at low geomagnetic latitudes, the occasional presence of the Z-component at low latitudes has been attributed to the partial reflection and transmission process which may take place at all latitudes. The view that the Z-component really corresponds to the left-handed ordinary component suffering reflection at the level corresponding to $p_0^2 = p^2 + p \cdot p_H$ has been supported.

A

SAVENKO, I. A., P. I. Shavrin, and N. F. Pisarenko. Soft corpuscular radiation at an altitude of 320 km in latitudes near the equator. Iskusst. Sputniki Zemli 13, 75-80 (1962). (In Russian.)

An account is given of the measurements taken on the second Soviet earth satellite which provide direct proof of the existence of low-energy charged particles at altitudes of about 300 km from the earth's surface in equatorial latitudes.

PA

SAWADA, K., and H. Shibata. World maps of f_0F2 during the IGY. J. Radio Res. Lab. (Japan) 37, 219-286 (1961).

Advantage was taken of the very large number of observation stations widely distributed throughout the world during the IGY, to compile a series of maps showing the world distribution of f_0F2 characteristics during a year in which the sun was in record-breaking activity, the Wolf's sunspot number being 200 or more and the conditions in the ionosphere consequently unusual, so that the world distribution of the characteristics for such a period may have a special significance. The results of the observations are briefly discussed and special features of the maps are noted, particularly as regards longitudinal and latitudinal effects. The first set of 24 maps show the f_0F2 contours at Oh/ and 12h/LT for each month of 1945, while the second set of 96 give the contours at 3h intervals from 0 to 24h/ UT for each month of the year, the whole series being reproduced on the last 60 pages of the paper.

SAYERS, J., P. Rothwell, and J. H. Wager. Evidence for a further ionospheric ledge above the F2 region. Nature 195, 1143-1145 (1962).

Satellite Ariel, which was launched from Cape Canaveral on April 26, 1962, carries instrumentation to measure the local ionization density along the path of the satellite. These data are stored point by point along each orbit by a tape recorder on board the satellite, and relayed by fast playback over the telemetry link on command from a ground station. Ariel is, therefore, the first satellite with instrumentation and a data-recovery system capable of providing a rapid world-wide survey of the distribution of ionization over the range of altitude and latitude covered by its orbit. This, in effect, means a scan of ionization between latitudes 54° N. and 54° S., and in the geocentric altitude range of 400–1,200 km.

SCHLAPP, D. M. Some measurements of collision frequency in the E-region of the ionosphere. J. Atmos. Terrest. Phys. 16, 340-343 (1959).

Measurements of collision frequency in the E-region were made by observing how the deviative absorption of a radio echo varied with its group path as a critical frequency was approached. The collision frequency at heights between 105 km and 120 km was found to vary with a scale height of about 16 km. In 1955, the collision frequency passed through a value of 2×10^4 $\sec^{-1}$ at a height of about 112 km. There is some evidence that, when the sunspot number is greater, the collision frequency at a fixed height is greater.
A

SCHLAPP, D. M. An attempt to measure the collision frequency of electrons in the F-region of the ionosphere. J. Atmos. Terrest. Phys. 17, 246-253 (1960).

An attempt was made to measure the collision frequency (ν) of electrons in the F-region of the ionosphere by Appleton's method of observing changes in the logarithmic reflection coefficient log ρ associated with changes ($\Delta P'$) in the group path, and using the expression.

$$\Delta \log \rho = - \frac{\nu}{2c} (\Delta P' - \Delta P)$$

It is shown that the experimental results were very variable and that the average of a large number behaves in a way which is not in accord with theory. It is concluded that, in the F-region, ν is less than about 5×10^3 $\sec^{-1}$ but that no reliable estimates of its magnitude can be made by this method.
A

SCHMERLING, E. R. Ionospheric electron densities for Washington, D. C., Panama, Talara and Huancayo, Number 1, July 1957. Scientific Rept. 105, Contract AF 19(604)3875, Ionosphere Research Laboratory, Pennsylvania State University, University Park, Pa. (15 July 1958). AD-152 618.

Tables were computed from routine ionograms by a matrix method. Details of the method were previously discussed (AD-117 245). Two 40 by 40 matrices were used for each station (Washington, D. C., Panama, Talara, and Huancayo) to cover the ranges 1.6 (0.2) 9.6 and 2.0 (0.5) 22 mc. The method takes full account of the earth's magnetic field, but ignores electronic collisions. Several scaling practices were used for the E region cusps and E-F transitions. The tables give electron densities at 20-km intervals every hour for the regular world days and the 10 magnetically quietest days. Heights at the electron peaks are not well defined. Profiles are not reliable at the lowest heights because of the low-frequency cutoff on the ionograms. (See also AD-152 644).
DDC

SCHMERLING, E. R. Ionospheric electron densities for Washington, D. C., Panama, Talara and Huancayo, Number 2, August 1957. Scientific Rept. 108, Contract AF 19(604)3875, Ionosphere Research Laboratory, Pennsylvania State University, University Park, Pa. (1 August 1958). AD-152 644.

Tables were computed from routine ionograms by the matrix method of Budden (Phys. Soc., p. 332, 1955). The method takes full account of the earth's magnetic field, but ignores electronic collisions. No assumptions were made as to profile shape other than a monotonic variation of electron density with height. The individual electron density-height-profiles were drawn for each hour, and the peaks of the profiles sketched in by extrapolating to tangency with the peak electron density, as found from f_0F2. The tables give electron densities at intervals of 20 km every hour for the regular world days and the 10 magnetically quietest days.
DDC

SCHMERLING, E. R. Ionospheric electron densities for Washington, D. C., Panama, Talara, and Huancayo for October-November-December, 1957. Scientific Rept. 118, Contract AF 19(604)3875, Ionosphere Research Laboratory, Pennsylvania State University., University Park, Pa. (27 April 1959). AD-216 696.

No abstract available.
DDC

SCHMERLING, E. R., and C. A. Ventrice. Coefficients for the rapid reduction of h'-f records to N-h profiles without computing aids. J. Atmos. Terrest. Phys. 14, 249-261 (1959).

Tables of coefficients are presented by means of which h'-f records may be readily reduced to electron-density—height profiles without the use of computing aids. The tables presented are for any station whose magnetic dip angle does not exceed 80°. The ordinary ray trace is utilized. No special assumptions concerning profile shapes are made. Account is taken of the earth's magnetic field, but collisions are neglected.

The sensitivity of these coefficients to magnetic dip angle and gyrofrequency is discussed. Sample h'-f records are reduced by means of the coefficients and the results are compared with those from the Budden matrix method.

A

SCHMERLING, E. R. Effects of vertical diffusion of electrons near the magnetic equator. Nature 188, 133-134 (1960).

It is considered that vertical diffusion accounts for the major features of the geomagnetic anomaly, and that this anomaly consists of excess ionization, due to diffusion, away from the equator, rather than a deficiency of ionization at the equator. This thesis is supported by some simple calculations.

PA

SCHMERLING, E. R. Ionospheric electron densities for Washington, D.C., Panama, Talara, and Huancayo for July-August-September, 1958. Scientific Rept. 130, Contract AF 19(604)3875, Ionosphere Research Laboratory, Pennsylvania State University, University Park, Pa. (1 March 1960). AD-237 684.

No abstract available.

DDC

SCHMERLING, E. R. Ionospheric electron densities for Washington, D.C., Panama, Talara, and Huancayo for October-November-December, 1958. Scientific Rept. 136, Contract AF 19(604)3875, Ionosphere Research Laboratory, Pennsylvania State University, University Park, Pa. (1 Aug. 1960). AD-240 555; GRD TN 60-497.

No abstract available.

DDC

SCHMERLING, E. R. Some results of an I.G.Y. true height survey. Publication 880. National Research Council U.S., 193-194 (1961).

Some interesting facts were revealed when ionograms from Huancayo and Talara (Peru) and from Panama (Canal Zone) and Washington, D.C. were reduced to electron-density height profiles presented and discussed in the paper.
MGA

SEATON, S. L. Rate of electron production in ionosphere. Phys. Rev. 72, 712-714 (1947).

Methods for determination of rate of electron production in ionosphere throughout 24 hr; rate of electron production varies more or less systematically from zero before sunrise to values around 800 electrons $cm^{-3}sec^{-1}$ near noon at equator for equinoctial interval at sunspot minimum.
A

SELZER, E. Simultaneous recordings in France, at the equator, and in the Antarctic, of the magnetic effects resulting from the "Argus Experiment." Compt. Rend. 249, 1133-1135 (1959). (In French.)

The "Argus Experiment," a series of three nuclear explosions at about 480 km altitude above the South Atlantic Ocean, gave rise in each of the three cases to magnetic signals which were recorded with great sharpness and at precise moments at the French stations at Chambon-la-Foret, at Bangui and at those in the Antarctic. The analysis of the recordings prove: a) the signals spread over large parts of the terrestrial globe with a speed of about 1000 km/s at the surface without following the lines of force of the magnetic field; b) the easy penetration of the signals within the Antarctic auroral zone; c) the absence of a well defined oscillation period. The oscillations are in general fairly irregular and seem to line up roughly in two categories, around 1 and 2 sec. From this it appears that the interaction phenomena between the two types of toroidal and poloidal oscillations indicated by the terrestrial hydromagnetic waves must be much more important than the present fundamental theories led us to believe.
MGA

SEN, Hon Yung. Stratification of the F2-layer of the ionosphere over Singapore. J. Geophys. Res. 54, 363-366 (1949).

Ionospheric measurements made in Singapore in January and February, 1946, indicated that the F2-layer was daily stratified into three discrete layers during the daylight hours. Typical h'-f curves during the day and the diurnal-variation graphs are reproduced.

SEN, N. N. Relation between the auto-correlation coefficients of singly- and multiply-reflected radio waves. J. Atmos. Terrest. Phys. 26, 25-30 (1964).

A relation between the auto-correlation coefficients of the fading curves of the first and the second returns from the Ionosphere was deduced earlier by Booker et al. (1950). In this paper relations between the auto-correlation coefficients of the fading of the first and the third returns and then between the auto-correlation coefficients of the first and the nth returns from the ionosphere have been deduced.

An experimental verification of the relations between the first three orders of reflections from the ionosphere has also been given.

A

SEN GUPTA, B., D. N. Chaudhuri, and S. R. Khastgir. Ionospheric height measurements in eastern Bengal by the method of signal fading. Phil. Mag. 22, 132-144 (1936).

Experiments are described in which simultaneous observations were taken at short time intervals of the intensities of fading of the Calcutta signal (λ = 370·4 m., distance = 240 km.) received at Dacca on a loop and a vertical aerial. The theory of a modified form of Appleton and Barnett's method of measuring the angle of incidence of the atmospheric waves is described. The method claims simplicity in experimental technique. Evidence is obtained of multiple reflections at the E-layer. The average height of the E-layer is found to be 106 km. In some cases the height is found to be distinctly greater, the mean of such values being 137 km. The result indicates that the E-layer may lie between these limits.

There are strong indications of occasional penetration of the E-layer by the 370-m. waves, and of simultaneous reception of the E_1- and F_1-rays on certain occasions, indicating that the electron density of the E-layer has been on these occasions greater than 3×10^3 and less than 6×10^3 electrons/cm^3. during the hours of observations. This "patchy" nature has been previously reported. The average height of the F-layer is found to be 215 km.
A

SETHURAMAN, R. Rates of fading of reflected pulses of vertically incident electromagnetic waves at Ahmedabad on 2.6 and 4.0 Mc/s. J. Sci. Indus. Res. 17A, 50-53 (1958).

Summarized results of the Physical Research Laboratory's observations at Ahmedabad Oct. 1956 - March 1958 show that: (1) rapid fading < 5 sec. period occurs mainly during night hour and is somewhat dependent on magnetic activity; (2) low values of C_p is generally associated with more rapid fading, and the F_2 reflections exhibited a marked correlation with the amount of spread of the p^1-f records; (3) nighttime F_2 is sensitive to magnetic activities which daytime E layer is not.
N

SHAPIRO, I. R., J. D. Stolarik, and J. P. Heppner. The vector field proton magnetometer for IGY satellite ground stations. J. Geophys. Res. 65, 913-920 (1960).

By applying homogeneous bias fields to a proton precessional magnetometer, vector magnetic field measurements of exceptional accuracy can be obtained. A vector proton magnetometer that has been in operation at nine Minitrack stations since the spring of 1958 is described.
A

SHCHEPKIN, L. A. The problem of the geographical distribution of critical frequencies of the F2 layer in the low latitudes. Geomagnetism and Aeronomy II, 307-309 (1962).

A detailed study of the latitudinal dependence of the critical frequencies of the F2 layer - $f_0F2(\phi)$ - has made it possible in recent years to detect not only a clearly defined geomagnetic effect, but also a tendency for a definite dependence on solar elevation. The clearest expression of this dependence is in the shifting of the f_0F2 peak during the day [1]. From morning to noon this peak shifts from the low to the high latitudes, and after 1400 hours local time - in the opposite direction. The diurnal curve of f_0F2 also shows a tendency to change with latitude, which is manifested as a function of both geographic and geomagnetic coordinates. A remarkable peculiarity of the latter dependence is the presence of two peaks on the curve of the diurnal variation of f_0F2 - post-midday and post-midnight, the convergence of these peaks with an increase of latitude and their merging into a single large midday peak at some latitude.

SHCHEPKIN, L. A. Latitudinal change of conditions for the occurrence of the F1 layer. Geomagnetism and Aeronomy (Moscow) III, 1053-1058 (1963).

The article cited below is based on a study of the latitudinal change of the conditions for the occurrence of the F1 layer during a period of high solar activity at the solstices. The probability of occurrence of the F1 layer when the sun is low above the horizon has an obvious tendency to an increase with an increase in latitude. The value of the cosine of the solar zenith angle, corresponding to the commencement of the regular occurrence of the F1 layer in the daily cycle decreases with an increase in latitude. There is a tendency to maximum values of the cosine of the solar zenith angle at geographic latitudes ~20° in the summer hemisphere. Improvement of the conditions for the formation of the F1 layer with an increase of latitude also is manifested in an increase in the relative number of cases of well-developed layers. A study of its changes seasonally also leads to the same conclusion with respect to the latitudinal change of conditions of the occurrence of the F1 layer. There is a discussion of the possible reasons for the considered latitude effect, proceeding on the basis of concepts concerning the role of splitting of the maximum of ion formation in the F region of the ionosphere in the formation of the F1 layer.

SHERIFF, R. M. A study of the total electron content of the F-region of the ionosphere over Ahmedabad (23°N, 72°38'E), India. J. Atmos. Terrest. Phys. 8, 91-97 (1956).

Calculated total subpeak F1- and F2-region electron density for 3 magnetically quiet days and 3 disturbed days each month from Feb 1953 to Jan 1954. Analysis based on parabolic distribution. Plots mean daily variations for 3 seasons. Finds thick layers have higher peak height and nonparabolic distribution.
M

SHIBATA, H., K. Sawada, and S. Taguchi. Longitudinal and latitudinal effect of the ionosphere estimated by observation on board the Soya. J. Radio Res. Labs. (Japan) 7, 575-582 (1960).

Routine determinations of f_0F2 were made en route between Japan and Antartica in four successive years from 1956. It is shown that from the results, a valid estimation of the latitudinal and longitudinal variation of f_0F_2 can be made.

SHIMAZAKI, T. Effect of the S_q current system on the ionospheric E- and F1-layers. J. Atmos. Terrest. Phys. 15, 77-82 (1959).

The discrepancy between the observed f_0E or f_0F1 and those predicted by the Chapman theory was examined in detail. The result shows that the F1-layer varies in a manner more regular than the E-layer, and that the discrepancy in the E-layer may be attributed partly to the effect of scale height gradient, but the principal cause certainly lies in the effect of S_q overhead current system. Discussion is made on the non-uniform motion of vertical drift velocity produced by this effect, as well as on the recombination coefficient and the scale height gradient in these regions.
A

SHIMAZAKI, T. Dynamical structure of the ionospheric F2-layer as deduced from the world-wide daily variations. J. Atmos. Terrest. Phys. 15, 108-115 (1959).

Recourse was made to numerical calculations to find the effects of various non-uniform vertical motions due to diffusion, thermal and/or tidal variations on daily variations in the F2-layer. A method of solving the problem was worked out so that the electron density distribution may return back every 24 hr regardless of non-recurrent motions of each part resulted by several causes. The comparison of calculated and observed variations shows that the Bradbury model is better than the Chapman model in every respect. Special emphasis is placed upon the fact that the effect of non-uniform semi-diurnal vertical drift velocities with height gradient of both amplitude and phase is very important except near the equator.
A

SHIMAZAKI, T. A statistical study of world-wide occurrence probability of spread F, Part I, Average State. J. Radio Res. Labs. (Japan) 6, 669-687 (1959).

A statistical study of the occurrence probability of spread-F is made by the use of the IGY data for the whole world. The daily, latitudinal and seasonal variations of the probability are clarified. The comparison with the sunspot minimum year (1954) is also made. The statistical analyses are made for all sorts of days, including magnetically quiet or disturbed days. The result shows that all of the statistical properties much differs at higher and lower latitudes. This may suggest that the origin of spread-F essentially differs at these two latitudes. The entry of charged particles into the upper atmosphere certainly causes the spread-F at higher latitudes, while at lower latitudes the origin must be sought in the terrestrial atmosphere.
A

SHIMAZAKI, T. A statistical study of world-wide occurrence probability of spread F, Part II, Abnormal state in severe magnetic storms. J. Radio Res. Labs. (Japan) 6, 688-704 (1959).

An investigation is made into the correlation between the occurrence probability of spread-F and the geomagnetic activity. The result shows that the correlation is strongly negative at lower latitudes (<20°), while it is strongly positive at latitudes between 20° and 60°. At higher latitudes (>60°), the correlation becomes negative again, but it is shown that the result is much influenced by the occurrence of "black-out".

The abnormal state of the world's occurrence probability in some severe magnetic storms is studied in full detail. The result can be well explained by the consideration that the critical level of the charged particles penetrating into the upper atmosphere rises gradually with the decrease of latitude. At latitudes lower than a certain critical latitude, the effect of magnetic storms is not so appreciable.
A

SHIMAZAKI, T. The diurnal and seasonal variations of the occurrence probability of spread-F. IN: Beynon, W. J. G., ed., Some Ionospheric Results Obtained During the I.G.Y., Proc. Symposium URSI/AGI Committee, Brussels, Sept. 1959, 158-164, (Elsevier Publishing Co., New York, 1960).

A statistical study of the occurrence probability of spread-F is made using I.G.Y. data (July, 1957-June, 1958) for the whole world. The daily, latitudinal and seasonal variations of the probability are clarified. The analysis is made for all days, including magnetically quiet or disturbed days. The method of analysis, the main results obtained and a brief discussion of the results are given.
A

SHIMAZAKI, T. The world-wide occurrence probability of spread-F in severe magnetic storms. IN: Beynon, W. J. G., ed., Some Ionospheric Results Obtained During the I.G.Y., Proc. Symposium URSI/AGI Committee, Brussels, Sept. 1959, 165-171. (Elsevier Publishing Co., New York, 1960.)

An investigation is made into the correlation between the occurrence probability of spread-F and geomagnetic activity for individual days. The abnormal state of the world morphology of the occurrence probability of spread-F in some severe magnetic storms is studied in full detail. The results support the consideration that the spread-F appearing at higher latitudes is due to the entry of charged particles into the earth's upper atmosphere.
A

SHIMAZAKI, T. A comparison of horizontal ionospheric drifts at different latitudes. IN: Beynon, W. J. G., ed., Some Ionospheric Results Obtained during the I.G.Y., Proc. Symposium URSI/AGI Committee, Brussels, 1959, 34C-354 (Elsevier Publishing Co., New York, 1960).

A comparison is made between daily and seasonal variations of ionospheric drifts at four stations (Cambridge, Freiburg, Yamagawa and

Waltair) located in higher, middle and lower latitudes. Figures showing daily variation of NS and EW components of drift velocity in each season at each station are plotted as well as the yearly mean curves at Cambridge and Yamagawa. Drift measurements were carried out for the E and F layers and the prevailing diurnal and semi-diurnal components of variations at each station are presented in graphs.

SHIMAZAKI, T. The occurrence of the spread-F and the geomagnetic field. J. Radio Res. Labs. (Japan) 7, 437-456 (Sept. 1960).

The effect of a geomagnetic storm on the occurrence of the spread-F is first studied. The storms that occurred during January 1957 to September 1959 are classified into several groups according to their intensity and the time (in U.T.) or the season of Sc, and then the occurrence probability of the spread-F is compared with each other of various days before and after Sc for each group of the classification. The result shows that the probability increases appreciably on days after Sc at higher latitudes, while it decreases at lower latitudes. This is most remarkable in the groups of highest intensity or of equinoctial seasons, although the tendency is appreciable even in the group of lowest intensity.

It is also shown that the correlation between the occurrence probability of the spread-F and the magnitude of the geomagnetic field is strongly positive at lower latitudes. This might be understood from the consideration that the turbulence is produced as the result of the breakdown of stability of the laminar flow (ionospheric winds), which may become easier to be destablized by the applied magnetic field.

SHINN, D. H. and H. A. Whale. Group velocities and group heights from the magneto-ionic theory. J. Atmos. Terrest. Phys. 2, 85-105 (1952).

In Part I the group velocity of a radio wave in the ionosphere above South East England is calculated for the ordinary and extraordinary wave for a wide range of frequencies. Results are presented in the form of curves. A sufficient number of values has been calculated for group delays at vertical incidence to be computed. In Part II similar values for various angles of dip are used to find the shapes of the group height vs. frequency curves, for the ordinary ray vertically incident on a parabolic layer, at various magnetic latitudes. Estimates of height of maximum ionisation and thickness of layer from observed group height vs. frequency curves

have until now been based on calculations in which the effect of the magnetic field is neglected. It is shown that such estimates of layer thickness are correct on the magnetic equator, but yield values which are too high by about 17% at magnetic latitude 27° rising to about 53% at magnetic latitude 62°. Estimates of height of maximum ionisation are, however, approximately correct. A modification to the present method of estimating these parameters is proposed. The effect of the field on oblique incidence propagation is discussed, but no exact conclusions are reached.
A

SHIRGAOKAR, A. J., M. Yasuhara, and H. Maeda. World-wide geomagnetic effects of the 9 July 1962 Johnston Island nuclear explosion. Rept. Ionosphere Space Res. Japan 15, 420-424 (1962).

At about 09:00 G.M.T. of July 9, 1962 a 1.4-megaton nuclear bomb was exploded at a height of 250 miles (about 400 km) above Johnston Island, and its effect have been observed at geomagnetic stations all over the world. The purpose of this communication is to indicate, in some detail, world-wide geomagnetic effects of the high-altitude nuclear explosion, and to discuss the cause of those effects. Magnetograms received from Addis Ababa (AA), Alibag (Al), Amberley (Am), Annamalainagar (An), Apia (Ap), Aso (As), Bangui (Bg), Churchill (Ch), College (Co), Fredericksburg (Fr), Gnangara (Gn), Göttingen (Gö), Guam (Gm), Hartland (Ht), Helwan (Hw), Hermanus (Hm), Hollandia (Hd), Honolulu (Ho), Huancayo (Hu), Kanoya (Ky), Kakioka (Kk), Lerwick (Le), Luanda (Lu), M'Bour (MB), Memambetsu (Me), Muntinlupa (Mu), Port Moresby (PM), Rude Skov (RS), San Juan (SJ), Simosato (Sm), Sitka (Si), Sodankylä (So), Teoloyucan (Te), Trivandrum (Tr), Tucson (Tu), Victoria (Vi), and Witteveen (Wi) observatories have been used in this study.
Excerpt

SHIRKE, J. S. Ionospheric absorption on 2.5/2.6 Mc/s. at Ahmedabad. Proc. IGY Symposium I, 142-148.

Measurements of ionospheric absorption using vertical pulsed transmission were carried out at Ahmedabad on 2.5 Mc/s. from August 1957 to April 1958 and on 2.6 Mc/s. from May 1958 to February 1959.

The data show that the mean monthly values of absorption, L, obey a relation, $L \propto \cos^{n} x$, where x is the zenith angle of the sun, the mean value of n being 0.70 for 2.5 Mc/s. and 0.80 for 2.6 Mc/s. The value of n was 0.86 for summer, 0.69 for winter and 0.74 for the equinoxes.

For removing the seasonal variations, the values of absorption were extrapolated to $\cos x = 1$. These extrapolated values showed a linear dependence on the sunspot number R. It was observed that $L' = L_0 (1 + \beta R)$, where $L_0 = 47$ db. and $\beta = 0.0020$ for 2.5 Mc/s.; and $L_0 = 45$ db. and $\beta = 0.0018$ for 2.6 Mc/s.

SHIRKE, J. S. Measurement of the ionospheric absorption on 2.5 mc/s at Ahmedabad. J. Inst. Telecom. Engrs. 5, 115-120 (1959).

Measurements were carried out at Ahmedabad (latitude 23°0'N, longitude 72° 6'E) using vertical pulsed transmission from August 1957 to July 1958. The strength of the transmitted signal was kept constant and the intensities of the vertically reflected pulses were reduced by the use of a passive attenuator so as to give constant intensity of signal on the oscilloscope screen of the receiving circuit. It was found that mean monthly values of the absorption plotted against cos X for each month from August 1957 to July 1958 obeyed a relation of the type $\log \rho \propto \cos^{n} X$. The value of "n" for individual months ranges from 0.64 to 0.89 and the mean value is 0.73. To eliminate the effects of seasonal changes in the noon zenith distance of the sun, values of absorption for $\cos X = 1$ were obtained by extrapolation. These extrapolated values show fairly close correlation with the sunspot number. Generally, maximum absorption is reached some time after local noon, suggesting relaxation time for D region. Absorption larger than that expected by the cos X law is observed in the late evening hours. This is attributed to a contribution from the deviative type of attenuation in the E layer.
EEA

SHIRKE, J. S. F-scatter and cosmic radio noise on 25 mc./s. at Ahmedabad. Proc. Indian Acad. Sci. 56A, 165-170 (1962).

Examination of the smic noise records at 25 Mc, which are maintained continuously at Ahmedabad, India. From these records, pronounced

fluctuations are observed which are sometimes associated with ionospheric F-scatter. A dependence of the fluctuations on sidereal time is also observed. Cosmic noise attenuation increases if the F-scatter occurs at an hour of maximum cosmic noise, and decreases if the scatter occurs at the time of minimum cosmic noise. An explanation of the observed effects is offered in terms of the scattering of the cosmic radio waves by spatial variations in electron density. Sporadic E is found to have negligible effect on cosmic noise absorption on 25 Mc.
IAA

SHIRKE, J. S., and S. K. Alurkar. Solar flare (S.I.D.) effects on the propagation of 164 kc/s radio-waves from Tashkent to Ahmedabad. Proc. Indian Acad. Sci., 47A No. 2, 49-64 (1963).

Continuous recording of cosmic radio noise on 25 Mc./s. is being made at Ahmedabad (23°01'N, 72°36'E) since 1956. Solar flares are well shown on these records. A list of the observed flares during 1956-58 together with an analysis has been published by Bhonsle (1960). The effect of a solar flare is to cause a sudden increase in the attenuation of the 25 Mc./s. followed by a slower rise to normal. The whole phenomenon lasts for less than an hour. There is evidence to show that a large part of the increased attenuation takes place in the D region of the ionosphere. It was suggested by Dr. K. R. Ramanathan that it would be useful to supplement the above study by comparing it with the changes imposed on the field strength of low frequency radio-waves propagated over a long distance, preferably along a meridian.

Since March 1960, regular recording of field strengths of Tashkent radio transmissions on 164 Kc./s. has been made at Ahmedabad. The paper contains an analysis of the 115 sudden ionospheric disturbances (S.I.D.'s) which were recorded during the period March to December 1960. Only a few of them were associated with visible solar flares.

Many of the S.I.D.'s occur simultaneously with S.C.N.A.'s (Sudden Cosmic Noise Attenuations) on 25 Mc./s. which are also recorded continuously. On some occasions when the altitude of the sun is low, there is a weakening of the L.F. signal a few minutes before the onset of the noise burst or S.C.N.A. An explanation of the observed phenomena is suggested.
Excerpt

SHIRKE, J. S. A comparison of electron density profiles in Ahmedabad in years of low and high solar activity. J. Atmos. Terrest. Phys. 25, 429-440 (1963).

The median vertical distributions of electron density over Ahmedabad (23°01 N, 72°36 E) in January, April, July and October in the years of low and high solar activity 1954 and 1957-1958 have been calculated from ionograms. A method suggested by King (1960) has been used for the calculation. The P'f records on all the days of the month for the same local hour were superposed and the monthly median p'f curve interpolated. This was then subjected to true height analysis by applying the standard Schmerling method used for the analysis of individual curves.

The diurnal electron densities are presented in the form of iso-electron-density contours against height. The curves are extrapolated above the level of maximum electron density assuming Garriott's model for the distribution. The major features of diurnal and seasonal variation are discussed.

A

SIGNAL CORPS RADIO PROPAGATION AGENCY. Calculation of sky-wave field intensities, maximum usable frequencies, and lowest useful high frequencies. Tech. Rept. 6, U. S. Army Signal Corps, Radio Propagation Agency, Ft. Monmouth, N. J., (Second Printing, June 1954).

a. In this report, practical methods for calculating various sky-wave communication problems are shown. The solutions are mainly graphical, no mathematics being required outside of arithmetic manipulation. The basic curves and nomograms used in the solutions are obtained from the statistical analysis of field intensity recordings for various radio circuits throughout the world. The methods show how to calculate what the most suitable frequencies are for any radio circuit at any time. By using these methods, one can determine whether communication is possible or not at various frequencies and what requirements are necessary in the equipment. The principal problem considered is the determination of the frequency limits between which a particular radio circuit can be operated. The upper limiting frequency is determined by the extent of ionization of the various layers while the lower limiting frequency is determined by the losses that a radio wave suffers and the noise conditions. The methods correspond to normal conditions in the ionosphere. The effects of ir-regularities such as ionospheric storms and sudden ionospheric disturbances are not accounted for while the effects of auroral activity are accounted for

under average conditions. The methods can be applied under any range of distances and for any period of time. Distances are divided into two ranges for field intensity and lowest useful high-frequency calculations: short distances, 0 to 3000 kilometers; and long distances, 3000 kilometers and greater. Nomographic solutions are given for problems in the long distance range while the curves are given for the short distance range.

b. Frequencies from 3 to 30 megacycles per second are usually called the short-wave band. Most sky-wave circuits are designed to operate in this frequency range. Sky-wave communication is possible for long distance circuits through regions of low latitudes at higher frequencies during periods of high solar activity. During the peak of the 11 year sunspot cycle, the F2 layer can support long distance communication at frequencies as high as 50 megacycles per second or more. The sporadic E layer may support long distance communication at frequencies as high as 75 megacycles. Sky-wave communication is generally used in any circuits for those distances for which only sky-wave communication is possible. Sky-waves suffer much less absorption than ground-waves and are the only suitable means for long distance circuits. Because of the large number of radio circuits used in the short-wave band, communication in this band may be subject to severe interference from both local and distant stations. Sky-wave communication should be avoided whenever it is practical. Frequencies in the very high frequency band from 30 to 300 megacycles should be used for communication over short or moderate distances whenever possible. At these higher frequencies, the possibility of interference and enemy interception is quite low. For point-to-point radio circuits, highly directional antennas can be used to limit the radiation to only the required direction. For very short distances of a mile or so, sky-wave communication may be the only possible means in jungle due to excessive ground-wave absorption in cases where the antenna cannot be raised above the jungle growth.

Excerpt

SIGNAL CORPS RADIO PROPAGATION AGENCY. Ground-wave field intensities including ground wave field intensities within the line of sight. Tech Rept. 3, U. S. Army Signal Corps Radio Propagation Agency, Ft. Monmouth, N. J. (second printing April 1956).

a. This report was prepared to show in a graphical form the expected ground-wave field intensities for vertical polarization for frequencies from .1 to 300 megacycles per second. The field intensities for elevated antennas within certain distance limitations are obtained by multiplying values obtained for antennas located at the ground by height gain factors. These ground-wave field intensities are based mainly on theoretical calculations for transmission over smooth spherical earth.

b. The curves of this report are applicable over a wide range of distances for frequencies from .1 to 300 megacycles, provided the antenna heights are not too great. Ground-wave field intensities are given within the line of sight for antennas of low electrical heights. Assuming both antennas are elevated 50 feet, the ground-wave field intensities can be found over fertile (good) ground from about 15 to 2000 miles for frequencies from 10 to 300 megacycles. The curves give a first approximation to ground-wave field intensities for elevated antennas for points where the height gain factor limitations are not fulfilled. The ground-wave field intensities at large heights within the line of sight are of values between twice the field intensity expected from the antenna in free space to a very low value. Figure 1 shows this maximum value (inverse distance) for various distances and effective powers. (The effective power is defined in this report as the product of the antenna gain with respect to short vertical grounded dipole and the antenna power input in kilowatts.) There are nomograms in this handbook which can be used to find the field intensities for ground constants other than those for which the curves are drawn. The ground-wave curves can also be used to give an approximation of the field intensity expected for horizontal polarization, provided the antennas are sufficiently high. For antenna heights exceeding about 250 feet, the field intensity values over sea water are approximately the same for horizontal and vertical polarization at 10 megacycles, while at 300 megacycles the values are practically alike, provided the antennas exceed 10 feet in height.

c. The ground-wave curves of this report are drawn for average atmospheric conditions. The curves are based on standard atmosphere in which the index of refraction decreases linearly with height at a rate of $.039 \times 10^{-6}$ per meter. Atmospheric refraction is taken into account by assuming an earth of an equivalent radius of 4/3 the actual radius. For different climatic conditions, the ground-wave field intensities differ somewhat from the values given. The equivalent radius factor which is taken at 4/3 in the temperate zone lies between 4/3 and 6/5 in the arctic, while it is between 4/3 and 3/2 in the tropics. This factor in the temperate and tropical climate is mainly determined by the change in relative humidity with height. It is relatively insensitive to the change in temperature with height. In the upper part of the very high frequency band, there are at times exceptional propagation conditions due to transmission in ducts. These unusual propagations are not considered in this report. For the frequency range considered, it can be assumed that weather conditions do not substantially effect ground-wave field intensities.

d. Ground-wave field intensities depend upon the electrical constants of the earth, the dielectric constant, and the conductivity. These constants are difficult to obtain accurately. The user can approximate the ground constants from the physical characteristics of the ground. The following table indicates the ground constants in MKS units for the different soils:

Type of Terrain	Dielectric Constant	Conductivity (MHO/M or EMU x 10^{-11})
Sea Water	80	5.
Fresh Water	80	.005
Moist Soil	30	.02
Fertile Ground	15	.005
Rocky Ground	7	.001
Dry Soil	4	.01
Very Dry Soil	4	.001

The ground-wave field intensity curves of this handbook are drawn for three types of terrain defined as good ground, poor ground, and sea water. The user can directly obtain ground-wave field intensities from these curves within the accuracy required for most applications. The constants of soil vary with weather conditions. Both the conductivity and dielectric constants increase with moisture content. The ground constants are lower in the winter than in the summer. They also vary with frequency. The constants of sea water vary with temperature, the dielectric constant diminishing and the conductivity increasing with temperature increases. The dielectric constant decreases with increasing frequency. For the frequency range considered in this report, it can be assumed that the variations of the constants with frequency can be neglected.
Excerpt.

SIGNAL CORPS RADIO PROPAGATION AGENCY. Radiation from antennas in the 2 to 30 megacycle band. Tech. Rept. 2, U. S. Army Signal Corps Radio Propagation Agency, Ft. Monmouth, N. J. (May 1958).

This report shows graphically the sky-wave and ground-wave radiation in the 2 to 30 megacycle frequency band from the following antennas:

Ground-Based Vertical
Ground-Based Inverted "L"
Horizontal Half-Wave
Horizontal Rhombic

The curves of this report are based mainly on theoretical calculations for assumed current distributions on thin wires. The ground system and antenna heat losses are accounted for by efficiency factors obtained from field measurements. The calculations consider the effects of the type of ground over which the antenna is erected in the ground reflection factors and antenna radiation resistances. It is assumed that the transmission lines are properly matched and that the antenna reactances are tuned out.

The unattenuated (inverse distance) field strength at a standard distance from a transmitting antenna in a given direction is a measure of

the amount of radiation in that direction. Sky-wave radiation is diminished in intensity only due to distance until the waves enter an absorbing or ionized region. One mile from an antenna sky-waves are not absorbed and, thus, have the inverse distance field intensity value. Waves propagated along the ground are attenuated due to ground losses. For groundwaves the inverse distance field intensity is the field intensity value if no transmission losses were present.

The antenna radiation curves of this report show the inverse distance field intensity in "radiated power" plotted against frequency for various radiation angles with an antenna input power of one kilowatt. Here 1000 watts "radiated power" is defined as an inverse distance field intensity of 186.3 millivolts per meter at one mile. If the inverse distance field intensity is 200 mv/m at one mile its value in radiated power is $(200/186.3)^2$ x 1000 "watts" or 1153 "watts". The nomogram on page 10 can be used to convert millivolts per meter at one mile into radiated power or vice versa. Radiated power is convenient to use in the solution of propagation problems (see Radio Propagation Unit Technical Report No. 6).

For values of antenna power input other than one kilowatt, the radiated power is the value from the curves multiplied by the power input in kilowatts. For an example, multiply the curve values by .3 when using an antenna input power of 300 watts (SCR-499 on radiotelephone service).

In order for a sky-wave to reach the receiving location it must be returned earthward by one of the ionized layers of the ionosphere. A particular transmission distance and reflecting layer height determines the vertical angle Δ above the ground plane at which the antenna radiation must be known. The figure (Single Reflection Radiation Angle vs Great Circle Distance) on page 11 shows that the radiation Δ is 36° for 500 mile one hop transmission by the F_2 Layer (average layer height 200 miles). This same radiation angle is required for two hop 1000 mile transmission for the same reflecting layer height.

Many antenna heights and lengths are given in this report in height (or length) to wave length ratios. Use nomogram on page 9 to obtain H/λ (height to wave length ratio) for any frequency from 1 to 40 megacycles and any height (or length) from 10 to 400 feet.

Excerpt

SILBERSTEIN, R. A long-distance pulse-propagation experiment on 20.1 megacycles. J. Geophys. Res. 63, 445-466 (1958).

A pulse-propagation experiment was performed between Sterling, Virginia, and Maui, Territory of Hawaii, with the object of studying the mechanism determining the classical MUF at long distances, and also of obtaining a general idea of the mode structure. Simultaneous oblique-incidence records of components has been discussed. A number of typical fading curves for short-wave radio signals transmitted from Delhi and Calcutta have been described. Particular reference may be made of curves which are very likely of magneto-ionic origin and depict the complete sequence of events expected when the value of the m.u.f. for the F2 layer passes across the signal frequency due to the increase or decrease of the ionic density of the layer. Fading curves which have been ascribed to interference between waves singly and doubly reflected from F2 layer and also those which are apparently caused by interference between waves simultaneously reflected from F2 and E layers have also been described and their features discussed. An example has also been given of such fading curves whose origin appear to be obscure.

A

SILVERMAN, S. M. and M. Casaverde. Behavior of the 6300 OI line at Huancayo. J. Geophys. Res. 66, 323-326 (1961).

The results presented in this paper confirm the findings of Delsemme and Delsemme (1960) and Barbier (1960) as to the unexpected behaviour of the forbidden red line of atomic oxygen in the night sky at latitudes near the equator. The results at Huancayo, Peru, show that the intensity of the 6300 OI line passes through a maximum at some time between 2200 and 0200 hours local time. Comparisons with observations at Tamanrasset and at Liviro indicate a strong seasonal effect on the intensities and also a strong latitude dependence of the phenomenon. It is noted that the diurnal variation for the red line is similar to that observed for the H component of the magnetic field in equatorial regions, though for this the maximum occurs at local noon.

PA

SINGER, S. F., E. Maple, and W. A. Bowen, Jr. Evidence for ionosphere currents from rocket experiments near the geomagnetic equator. J. Geophys. Res. 56, 265-281 (June 1951).

Records of magnetic field as a function of altitude have been obtained from total-field magnetometers mounted in two Aerobee sounding rockets. The flights were made 60 miles apart at approximately 89°W longitude, 11°S latitude, or geomagnetic longitude 341°, geomagnetic latitude -1°. In the first the field decreased between 20 and 105 km in accordance with the simple dipole field, while in the second a discontinuity of 4 ± 0.5 milligauss was observed in the altitude range of 93 to 105 km. These results (1) establish experimentally the existence of a current system in the E-region of the ionosphere which is responsible for the diurnal variation of the earth's magnetic field at sea level; and (2) lend strong support to the dynamo theory of the daily magnetic variation.
PA

SINGER, S. F. Rocket exploration of magnetic fields and electric currents in the upper atmosphere. IN: Boyd, R.L.F. and M.J. Seaton, eds., Rocket Exploration of the Upper Atmosphere, 256-260 (Pergamon Press, New York, 1954).

Tidal winds in the conducting layers of the Earth's atmosphere produce e.m.f.'s, and therefore a current system which is responsible for many of the geomagnetic variations observed at sea level. Rocket measurements at the magnetic equator have now established the existence of this current in the lower E-layer of the ionosphere. (1) Because of the insufficient conductivity of even the whole atmosphere in the presence of a transverse magnetic field it has always been difficult to account for the current on the basis of a theory which does not require excessively high wind velocities. The experimental result shows that the current is distributed in only a very narrow layer, extending from 93-105 km. (2) This finding forces a reconsideration of the theory of ionospheric conductivity. It leads t[illegible]e suggestion that by means of a Hall polarization, which is set up perpendi[illegible] to the electric field and the Earth's magnetic field, the conductivity at [illegible] equator is restored to the original high value which would exist in the absence of the magnetic field. In this way it is now possible to account for the ionospheric current system without invoking the presence of extremely high winds, i.e. velocities much greater than 100 km per hour.
A

SINGH, B. N., and R. L. Ram. A peculiar type of periodic fading. J. Atmos. Terrest. Phys. 13, 190-191 (1958).

During the course of observations on fading patterns of short-wave radio signals transmitted from Delhi on 25.62 m on the 22 March 1958 a peculiar type of pattern was recorded. This commenced from about 0115 hours (I.S.T.) and lasted for nearly an hour. A few of the patterns recorded during this period are shown in Figs. 1-3. The following features of the pattern may be noted.

Shortly before 0115 hours the pattern looked like a slow random type which gradually changed into a rhythmic one at about 0118 hours when the frequency was found to be 16 c/min. Very soon the beat nature of the periodic pattern appeared and at about 0125 hours while the frequency of the periodic pattern was about 17.5 c/min, the beat frequency was 1.28 c/min. The presence of beat indicates the existence of two periodicities of close frequencies. The beat frequency as well as the frequency of the periodic pattern fluctuated, but the beat nature of the pattern continued up to about 0155 hours. At about 0138 hours an additional periodic undulation appeared, superimposed upon the beat pattern. The former became more prominent at about 0212 hours while the beat feature practically disappeared.

From the available ionospheric data for the date and time concerned, the possibility of interference between singly and doubly reflected rays from the F2-layer was examined and found to be small. There was also no possibility of reflections from either the E-layer or the abnormal E-layer. Under such circumstances, the periodic pattern observed may be considered to be of Appleton-Beynon (1947) type, as the frequency of the radio signal for which the fading pattern was recorded was apparently close to the m.u.f. An attempt to receive transmission on 19 m band from Delhi was not successful during the period of observation.

The beat nature of the fading pattern conclusively indicate the existence of two periodicities of close frequencies and hence the presence of three reflected rays. If we consider the additional periodic undulation, we have to assume the presence of a fourth reflected ray. Appleton and Beynon (1947) have suggested the possibility of four reflections in case an oblique-ray suffers reflection from F2-layer near m.u.f. conditions. The four reflected rays in such a case would correspond to the upper and lower trajectory rays of the ordinary and extraordinary components. It is true that the chances of simultaneous reflections of these four types of rays would be small but, is possible under favourable conditions. What is, however, more surprising is the long duration of the periodic patterns. The periodic patterns observed by Appleton and Beynon (1947) lasted for only 14 min and the time during which two periodicities occurred simultaneously was even less. Some workers, e.g. Banerjee and Singh (1948), have no doubt reported the existence of magneto-ionic periodicity for a much longer time, but it was of a very small frequency and of a simple type.

Appleton-Beynon type of periodic patterns are usually obtained during morning and evening hours when the electronic-density of the reflecting layer is changing. This explains why they do not last for a long time. It may be suggested, however, that a similar periodic pattern may be obtained if the incident wave has a frequency very close to the m.u.f. of the F2 layer, and this layer is moving vertically without any appreciable variation in its electronic-density. Under such condition the periodic patterns may last much longer. Further investigations are in progress.

A

SINGH, B. N., and R. L. Ram. A complex periodic pattern of short waves. J. Geophys. Res. 63, 873-875 (1958).

A few interesting fading patterns were recorded at our laboratory on September 5, 1957, for radio transmissions from Delhi on wavelengths 19.79 m and 16.83 m, during 1030 to 1100 hours (IST). They are shown in Figures 1 and 2. The curves in Figure 1 are for the wavelength 19.79 m and were recorded from 1030 to 1035 hours. The curves in Figure 2 are for the wavelength 16.83 m and were taken from 1039 to 1044 hours. Even a casual glance at the Figures is enough to show that they are very much similar in nature and sequence. The curves are slow periodic type with quick periodic ripples superposed on them. The frequency of the slow as well as the rapid periodic curves decreases with advance of time. A closer observation reveals another interesting common feature of the two sets of rapid curves. Their amplitude, at least during a part of the time, appears to undergo a slow periodic variation. In both the Figures towards the end, the amplitude of the rapid periodicity increases. It is evident that the conditions and the sequence of events under which the curves in Figure 2 were obtained for the wavelength of 16.83 m must have been similar for the wavelength of 19.79 m when the curves shown in Figure 2 were obtained.

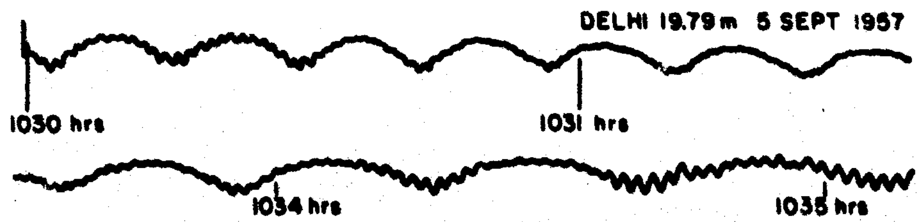

FIG. 1

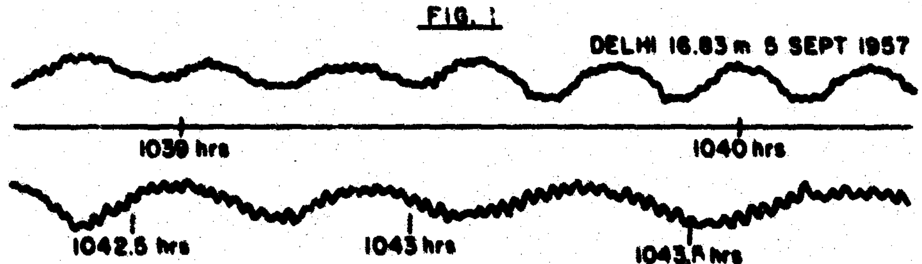

FIG. 2

SINGH, B. N. and R. L. Ram. Rhythmic fading of short-wave radio signals. J. Atmos. Terrest. Phys. 16, 145-146 (1959).

The problem of periodic fading due to interference of a number of components of a sinusoidal radio signal has been theoretically treated by considering it as equivalent to determining the resultant of a number of simple harmonic vibrations of nearly equal frequencies. The practical bearing of the results so obtained to fading curves of magneto-ionic origin particularly those caused by interference of three and four components has been discussed. A number of typical fading curves for short-wave radio signals transmitted from Delhi and Calcutta have been described. Particular reference may be made of curves which are very likely of magneto-ionic origin and depict the complete sequence of events expected when the value of the m.u.f. for the F2-layer passes across the signal frequency due to the increase or decrease of the ionic density of the layer. Fading curves which have been ascribed to interference between waves singly and doubly reflected from F2-layer and also those which are apparently caused by interference between waves simultaneously reflected from F2- and E-layers have also been described and their features discussed. An example has also been given of such fading curves whose origin appear to be obscure.
A

SINGH, B. N., and O. P. Simha. The variation of the rate of fading with frequency. J. Atmos. Terrest. Phys. 19, 141-143 (1960).

As early as 1932, Appleton had observed that the intensity fluctuations of the downcoming radio waves exhibit a kind of periodicity which is roughly proportional to their frequency. He also found that if T is the period of the fluctuations and λ the wave-length, T/λ increases monotonically with distance. During later years a number of workers (Pawsey, 1935; Harwood, 1951; Bowhill, 1953; King, 1958) have determined the periodicity of fluctuations, i.e. the fading speed for a wide range of frequencies with different angles of incidence. King (1958) has shown that if the night-time rate of fading is plotted against the frequency of radio signal multiplied by the cosine of the angle of incidence then the points are found to be scattered about a straight line represented by the equation:

$$\text{fading speed} = 0.30 \times f \cos i \text{ max./hr}$$

where f is the frequency in kc/s, and i is the angle of incidence on the ionosphere. The frequencies considered by King were up to 2000 kc/s and only two of them were for reflections from the F-region.

The present authors have determined in their laboratory the night-time fading speed of radio signals transmitted from A.I.R., Delhi, in

the frequency region 9605-17,783 kc/s. The values are given in Table 1 and are the mean of a large number of observations taken between 2300 and 0215 hours I.S.T. during different parts of the year. All the observations were for reflections from the F2-region. In calculating the values of cos i the height of the F2-region was assumed to be 300 km which was the mean of the values recorded over Calcutta and Delhi during the periods of observation, and the curvature of the earth was allowed for. The value of cos i thus calculated was 0.598.

The values of the fading speed for different values of f cos i as obtained from the above table and those given in Table 3 of the paper by King (1958) are plotted in Fig. 1. It may be noted that the points lie scattered about a straight line represented by an expression similar to that given by King (1958) except that the value of the constant is found to be 0.28 instead of 0.30. In Fig. 2 the fading speed for signals reflected only from the F-region are plotted against different values of f cos i. In this case also the points lie scattered about a straight line whose constant is 0.28. All these observations confirm the earlier conclusions of Appleton referred to above.
Excerpt

SINGH, R. N., and S. K. Tolpadi. Magnetic field of the F-region from h'-f records. J. Atmos. Terrest. Phys. 24, 824-826 (1962).

Some h'-f records were used to investigate the magnetic field in the F-region at New Delhi. The results are discussed in relation to the behaviour of the F-region.
PA

SINGH, R. N. Study of the sporadic-E layer from analysis of C-4 ionograms. J. Atmos. Terrest. Phys. 25, 589-595 (1963).

The C-4 ionograms taken at New Delhi during the period May 1958-May 1959 have been analysed. Different types of E_s are identified and their percentage occurrence is shown with the help of histogram. The blanketing of the E_s-layer is defined and its correlation with the occurrence of multiple E_s-reflection has been found. A positive correlation between the E_s occurrence, the critical frequency of the E_s-layer and the solar activity is obtained and is illustrated graphically. The effect of meteoric showers and sporadic meteors on the E_s-ionization is discussed.
A

SINGLETON, D. G. A study of "spread-F" ionospheric echoes at night at Brisbane. Austral. J. Phys. 10, 60-76 (1957).

Virtual range versus frequency (P'f) records of the ionosphere made at Brisbane (lat. 27·5°S., long. 152·9°E.) during 1952 and 1953 have been examined. It is found that occasionally neither the o nor the x mode of propagation penetrates the F_2 layer at a unique frequency, the upward-sweeping traces either being blurred out over a range of penetration frequencies (diffuseness) or possessing a fine structure (penetration-frequency multiplicity). Temporal analysis of the occurrence of these effects reveals that they occur only at night; penetration-frequency multiplicity appearing more frequently in the hours before dawn, while the diurnal distribution of diffuseness has a maximum between 0100 and 0500 hr in summer and represents a more even distribution between 2100 and 0500 hr in winter. The seasonal distribution has a pronounced peak in the winter months and minima in the equinoctial months. These data are compared with the world-wide picture of these variations as it has emerged from the recent literature.

The observations are interpreted in terms of scattering from the clouds of enhanced ionization near the F_2-layer maximum which are believed to be responsible for the scintillation of radio stars. It is suggested that there is a seasonal vertical movement of these clouds, the extent of which increases with latitude.

A

SINGLETON, D. G. The geomorphology of spread F. J. Geophys. Res. 65, 3615-3624 (1960).

An analysis has been made of reliable spread-F data obtained from IGY f plots for ionosonde stations grouped about longitudes 75° W and 120° E. The temporal variations of occurrence of the frequency-spreading component of spread F are found to change with latitude, these changes having a certain symmetry about the geomagnetic equator rather than about the geographic or dip equators. Four regions with different occurrence characteristics appear: two are regions of high activity, the auroral and equatorial regions; and the other two are regions of lower activity, the middle latitude and polar regions. The season of minimum occurrence in the equatorial region changes from the northern summer solstice in the American zone (75° W) to the southern summer solstice in the Far Eastern zone (120° E). This longitude effect, which led Reber to postulate the existence of a spread-F equator, is shown to be due to the interaction of some form of direct or indirect solar control with the magnetic control of the incidence of the phenomenon.

A

SINGLETON, D. G., G. J. E. Lynch, and J. A. Thomas. The scintillation of satellite radio transmissions and field-aligned ionospheric irregularities. Scientific Rept. 2, Contract AF 64(500)9, Queensland University, Australia (Sept. 1961). AD-286 375; AFCRL 62-302.

Three months' observations obtained at Brisbane of the scintillations of the 20 Mc/s transmissions from Explorer VII were analyzed in detail. The scintillations have a Gaussian distribution of amplitude and a scintillation rate which peaks at 2 c/s. The phenomenon is mainly a night-time one but some slight activity persists into the daylight hours. There is no evidence of a correlation with sporadic E but the scintillations are found to be associated with both the frequency-spreading and range-spreading types of spread-F. The scintillation activity is found to increase with zenith angle in a manner which can be interpreted in terms of the same system of irregularities, at heights of the order of 200 to 600 km., producing both the scintillations and spread-F. The irregularities are shown to be field-aligned and to have dimensions of the order of 1 km. The irregularities associated with frequency-spreading are found to occur in patches with horizontal dimensions of the order of 100 km. or more.
A

SINGLETON, D. G. Spread-F and the latitude variation of occurrence of whistlers. Nature 189, 215-216 (1961).

Recent work of whistling atmospherics has suggested that the incidence of the phenomenon is dependent on latitude. Crouchley, using data from Australian and Japanese stations, demonstrated that whistler activity reaches a maximum at about 45° geomagnetic latitude, while the Stanford group report a maximum of occurrence at 50° geomagnetic latitude. In both these reports a marked decrease in activity at lower and higher latitudes is noted. The decreasing incidence at higher latitudes has been attributed to decreasing thunderstorm activity, and rapidly increasing path-length and absorption with increasing latitude. However, the fall-off in activity at low latitudes cannot be so explained. Smith, Helliwell and Yabroff have suggested an explanation of this low-latitude fall-off in terms of whistler propagation within field-aligned ducts. They showed that the necessary ionization enhancement within the ducts for F-layer heights falls off markedly with increasing latitude and argue, therefore, that this suggests that whistler occurrence should increase with latitude, since large enhancements would be expected to occur less frequently than small enhancements. It is the purpose of this communication to examine this point in more detail.

The frequency-spreading component of spread-F has been interpreted as being due to the availability of a range of values of N_{max} at the maximum of the F_2 layer; this range of values is thought to correspond

to a system of irregularities each involving an enhancement (or a deficiency) of electron density relative to the background ionization. For any particular occurrence of frequency-spreading it is possible, in terms of this hypothesis and assuming critical reflexion conditions to apply, to calculate the ionization enhancement ($\Delta N/N$) required. It is now suggested that these postulated irregularities in the F_2-layer are, in fact, the lower extremities of the whistler ducts. If this is the case, then estimates of the electron density enhancements obtained from frequency-spreading information should support the contention of Smith et al. outlined above.

In work to be published elsewhere I have been able to fix limits to the range of values of ΔN observed at seven stations spread in geomagnetic latitude. Combining this information for a typical winter month with the monthly median critical frequency, it has been possible to produce, as shown in Fig. 1, a diagrammatic representation (shaded strip) of how the range of values of $\Delta N/N$ varies with geomagnetic latitude. (The position of that portion of the shaded strip bounded by dashed lines is less certain than elsewhere because of the low incidence of frequency spreading at these latitudes.) Also shown in Fig. 1 is the graph of minimum $\Delta N/N$ against geomagnetic latitude (dashed curve) due to Smith et al. and Crouchley's latitude distribution of whistler occurrence. (Since whistler activity is most pronounced in the winter months the latitude distribution of whistler activity is largely dependent upon winter conditions.) It will be noted that for latitudes less than about 30° the observed range of $\Delta N/N$ involves values considerably less than the values required by Smith et al. and that this corresponds to the region of low whistler occurrence. At 32° the largest observed value of $\Delta N/N$ corresponds to the minimum required for whistler propagation, while above 50° all the observed values of $\Delta N/N$ are of sufficient magnitude to support whistler propagation. The 30-50° latitude region corresponds to that in which the whistler activity increases. It seems, therefore, that the explanation of the latitude variation of whistler activity based on propagation within field-aligned ducts is consistent with ideas at present being used to interpret the frequency-spreading component of spread-F.

I am indebted to Mr. J. Crouchley and Dr. J. A. Thomas for their interest and helpful discussion.
Complete

SINGLETON, D. G. Scintillations and the latitude distribution of ionospheric irregularities. Nature 191, 482-483 (1961).

The author refers to recently reported observations of radio star scintillations. These show a considerable increase for latitudes north of 55N. Similar features have been noted with regard to scintillations from satellite signals. These scintillations can be correlated fairly closely with

the occurrence of spread-F, the distribution of which depends on the geomagnetic latitude and shows an increase of from 10 to 80% or more between 60° N and 70° N. This same distribution will explain the departure of the zenith angle dependence of the annual mean radio star scintillation index from the simple secant law as observed in Cambridge and in Manchester. Subject Headings: 1. Radio star scintillation 2. Satellite signal scintillations 3. Spread F.

SINGLETON, D. G. Spread-F and the perturbations of the maximum electron density of the F layer. Austral. J. Phys. 15, 242-260 (1962).

An analysis has been made of spread-F data obtained from I. G. Y. f-plots for several ionosonde stations grouped about longitude 75° W. to establish whether there is any connection between the severity of frequency-spreading (Δf) and the time of day, season of the year, magnetic activity, height of the F layer, critical frequency of the F layer, and the latitude of the ionosonde station. The diurnal variations of the severity of frequency spreading are found to vary considerably with latitude and season and no clear pattern emerges. Magnetic activity affects the value of Δf but again in a complex way which varies with latitude. The magnitude of Δf seems to be greatest when the layer is high and descending at low and middle latitudes but not at high latitudes. At all latitudes the magnitude of Δf is greatest when the critical frequency is lowest. This is considered to be the dominant effect having a profound influence on the diurnal and seasonal distributions of Δf. These results are discussed in terms of the hypothesis that frequency spreading is due to the availability of a range of values of $N_{max.}$ at the maximum of the F_2 layer. This range of values is thought to correspond to a system of irregularities each involving an enhancement or a deficiency of electron density relative to the background ionization. The extra ionization involved in the irregularities is estimated to be of the order of 10^5 electrons/c.c. and is found to vary little with season, magnetic activity, and latitude.
A

SINGLETON, D. G., and G. J. E. Lynch. The scintillation of the radio transmissions from Explorer VII. I. The nature of the scintillations. J. Atmos. Terrest. Phys. 24, 353-362 (1962).

Three months' observations obtained at Brisbane of the scintillations of the 20 Mc/s transmissions from Explorer VII have been analysed in detail. The scintillations have a Gaussian distribution of amplitude and a scintillation rate which peaks at 2 c/s. The phenomenon is mainly a night-time one but some slight activity persists into the daylight hours.

There is no evidence of a correlation with sporadic-E but the scintillations are found to be associated with both the frequency-spreading and range-spreading types of spread-F. The scintillation activity is found to increase with zenith angle in a manner which can be interpreted in terms of the same system of irregularities, at heights of the order of 200-600 km, producing both the scintillations and spread-F.
A

SINGLETON, D. G., and G. J. E. Lynch. The scintillation of the radio transmissions from Explorer VII-II. Some properties of the scintillation producing irregularities. J. Atmos. Terrest. Phys. 24, 363-374 (1962).

Three months' observations, obtained at Brisbane of the scintillations of the 20 Mc/s transmissions from Explorer VII, have been analysed in order to discover the nature of the ionospheric irregularities responsible. The irregularities are found to be field-aligned and to have dimensions of the order of 1 km. A considerable number of bursts of scintillation activity are found usually in association with the frequency-spreading type of spread-F but infrequently with the range-spreading type. This is interpreted as meaning that the irregularities associated with frequency-spreading have a more patchy horizontal distribution than those associated with range spreading. The horizontal dimensions of the patches are estimated to be of the order of 100 km or more.

SINGLETON, D. G. [illegible]read-F and the parameters of the F-layer of the ionosphere I. [illegible]read-F and F-layer electron density. J. Atmos. Terrest. Phys. [illegible] 871-884 (1962).

An analysis was mad[illegible] [illegible] spread-F data obtained from IGY f-plots for several ionosonde stations [illegible]ouped about longitude 75° W, to establish whether there is any connecti[illegible] between the incidence of spread-F and f_0F2, F-layer electron content, [illegible]d semi-thickness. It is found that the percentage occurrence of the fre[illegible]ncy-spreading component of spread-F at a value of f_0F2 increases as $1/f_0$[illegible] for all seasons and latitudes. This relationship is shown to be independe[illegible] of such associations as might exist between each of the two quantities invo[illegible]d and either the state of disturbance of the earth's magnetic field or the time [illegible] day. There seems to be no association between the incidence of freque[illegible] spreading and the rate of change of f_0F2, nor is there any association [illegible]h the electron content of the F-layer. However, frequency spreading is [illegible]ore likely to occur when the rate of change of electron content is positive [illegible]d to a lesser extent negative, at least at equatorial latitudes. At these [illegible]itudes, there is a

tendency for the incidence of frequency spreading to decrease with increasing semi-thickness up to about 100-150 km. This tendency then reverses, the incidence increasing with increasing thickness above about 200 km. Discussion of these results is postponed to a later paper in the series.
PA

SINGLETON, D. G. Spread-F and the parameters of the F-layer of the ionosphere. II. Spread-F and F-layer height. J. Atmos. Terrest. Phys. 24, 885-898 (1962).

An analysis was made of spread-F data obtained from IGY f-plots for several ionosonde stations grouped about longitude 75° W to establish whether there is any connection between the incidence of the frequency-spreading component of spread-F and the height of the F2-layer. It is found that the percentage occurrence of frequency spreading is greater the greater the height of the layer. This tendency is most pronounced in the equatorial and auroral regions and is found to be independent of season, time of day, and magnetic activity. Saturation of the direct relationship between percentage occurrence and F2-layer height is found to occur at heights ranging from 200 km at Baker Lake to 550 km at Huancayo. This association between the percentage occurrence of frequency spreading and layer height appears to be independent of the association between the percentage occurrence of frequency spreading and f_0F2 reported in Pt I. Discussion of these results is postponed to a later paper in the series.
PA

SINGLETON, D. G. Spread-F and the parameters of the F-layer of the ionosphere. III. Spread-F and the vertical movement of the F-layer. J. Atmos. Terrest. Phys. 24, 899-907 (1962).

An analysis was made of spread-F data, obtained from IGY f-plots for several ionosonde stations grouped about longitude 75° W to establish whether there is any connection between the incidence of the frequency spreading component of spread-F and the vertical movement of the F2-layer. It is found that at equatorial latitudes downward movement of the F2-layer is associated with the production of frequency spreading. Upward movement inhibits the production of frequency spreading at Huancayo and Talara. At latitudes above 60° geomagnetic, movement upwards or downwards results in increased frequency spreading activity. Minimum, but not zero percentage occurrence is associated with a stationary layer at these latitudes. These low- and high-latitude associations between the incidence of frequency spreading and the vertical movement of the F2-layer are found to be independent of magnetic activity, time of day, and season of the year. Discussion of these results is postponed to Pt IV.
PA

SINGLETON, D. G. Spread-F and the parameters of the F-layer of the ionosphere. IV. J. Atmos. Terrest. Phys. 24, 909-919 (1962).

The impact of the results of the previous parts of this series on the several theories of spread-F irregularity production is discussed. It is found impossible to reconcile the results with four of these theories, namely, Martyn's instability of the under surface of an upward drifting layer, Dagg's E-region turbulence communicated to the F-layer, Axford and Hine's convective motion of the magnetosphere and a theory of auroral particle origin of the irregularities. A new theory, based on initiation of instability of the surfaces of a drifting layer by hydromagnetic waves, is proposed. It is shown that this theory is in accord with the experimental findings.
A

SINGLETON, D. G. The spread-F equator. J. Atmos. Terrest. Phys. 25, 121-150 (1963).

An explanation of the position of the spread-F equator under sunspot maximum and sunspot minimum conditions is put forward. This explanation is based on the theory of spread-F irregularity production by Martyn amplification of irregularities initiated by hydromagnetic waves. It is shown that consideration of the spatial distribution of F-region critical frequency, height, and vertical motion in conjunction with the variation with latitude and season of hydromagnetic wave illumination of the upper ionosphere allows the position of the spread-F equator to be predicted.
PA

SIVARAMAKRISHNAN, M. V. A comparative study of geomagnetic and ionospheric changes at Kodaikanal and Huancayo. Indian J. Met. Geophys. 7, 137-146 (1956).

A study of geomagnetic field variations for five years, 1949 to 1953, and ionospheric changes during 1952-1954 at Kodaikanal reveals that Kodaikanal, situated near the geomagnetic equator, shows more or less the same anomalous behavior as Huancayo. The study shows: (i) Abnormal large range in the horizontal intensity H during quiet days, (ii) No abnormality in H during geomagnetic disturbances, (iii) Amplitudes of S.C.'s during noon are greater near the geomagnetic equator than at stations further away from it, (iv) A midday decrease of f_0F2 on quiet days (the bite-out effect), (v) Increase in the electron density of F2 layer with increase in geomagnetic activity conducive to better conditions for radio propagation,

and (vi) Occurrence of the lunar stratification of the F2 layer and its disappearance at the lunar times 0700 and 1930 h.
MGA

SKINNER, N. J., R. A. Brown, and R. W. Wright. Multiple stratification of the F-layer at Ibadan. J. Atmos. Terrest. Phys. 5, 92-100 (1954).

The ridges observed in the F_2-layer at Ibadan, Nigeria, have been recorded. There is a maximum occurrence of ridges around 1000 hours and 1500 hours. The morning ridges are more pronounced. A pronounced seasonal variation is found and most ridges occur when the midday minimum of f_0F2 occurs early in the day. A lunar variation is found in the rate of ridge information at 0900 hours. Ridges in F_1 are also discussed but it is concluded that there is little relation with those in F_2 and that the F1 ridges are connected with the E_2-layer. The observed facts can be explained by means of oscillatory vertical ionic drifts such as those suggested by Martyn (1947). Possible phases consistent with the phenomena are considered.
A

SKINNER, N. J., and R. W. Wright. F_2-layer regularities at Ibadan. J. Atmos. Terrest. Phys. 5, 290-297 (1954).

The mean daily variation throughout the year of n (the total electron content in a column of unit cross-section below the height of maximum ionization (h_m) in the F2-layer), and N_m (the maximum electron density of the F_2-layer), show clearly that n behaves in a more regular manner than N_m. It is shown that in calculating n, it is important to use values of the equivalent layer semi-thickness deduced assuming non-parabolic electron distributions where necessary. The Appleton-Beynon (1947) method for "parabolic" layers is not, therefore, completely adequate in tropical regions. Inclusion of the contribution by the F_1-layer to the total electron content has no appreciable effect upon the regularity of the diurnal variation of n.

A new method is described and used for deducing the coefficient of recombination (α), and the rate of ion production per cc (q), from the daily variation of n.

The pronounced sunset minimum in the virtual height of F_2, as reported by some observers, is discussed and considered to be largely spurious.

An h_m and y_m histogram is plotted and is found to be dissimilar to that at Huancayo, and similar to that at College, Alaska.
A

SKINNER, N. J., and R. W. Wright. Some geomagnetic effects in the equatorial F_2-region. J. Atmos. Terrest. Phys. 6, 177-188 (1955).

The diurnal variations of the values of many ionospheric parameters obtained at Ibadan, Nigeria, close to the magnetic equator, are investigated on magnetically quiet days and on magnetically disturbed days. It is found that the midday minimum of the maximum concentration of ionization N_m in the F_2-layer disappears as the days become more disturbed. On quiet days there is very little scatter of values of N_m, but on disturbed days this is much increased. Furthermore, both N_m and the total ion content, n, of a column of unit cross-section below the height of maximum ionization are greater at all times of the day on disturbed days than they are on quiet days. The perturbation of the quiet-day variation introduced on disturbed days, S_D, has not only a diurnal (twenty-four hours) component, but also a semidiurnal component. Whilst there is general agreement in the behaviour of the results described here and the theory of ionospheric disturbances proposed by Martyn [Abstr. 7350 (1953)], the data imply that the phases of the motions differ appreciably from those suggested by Martyn.
A

SKINNER, N. J., and R. W. Wright. Equatorial ionospheric absorption. J. Atmos. Terrest. Phys. 9, 103-117 (1956).

A study has been made of the variation of absorption with frequency and sun's zenith distance X at Ibadan at vertical incidence. Since the propagation at Ibadan is almost purely transverse, simple theories in terms of deviative and nondeviative absorption may be applied. It is found that the nondeviative absorption appears to obey a law of proportionality to the inverse frequency. The total absorption varies as $(\cos x)^n$, where n is about 0·7. These variations are accounted for by assuming that the nondeviative absorption takes place in a Chapman-type D layer at a level where the electron collisional frequency is of the same order as the angular frequency of the exploring radio signal.

Some comparisons are made with the absorption results from other stations. In particular, it is found that the frequency and seasonal variations at Singapore are similar to those at Ibadan.
A

SKINNER, N. J., and R. W. Wright. The effect of the equatorial electrojet on the ionospheric E_s and F_2 layers. Proc. Phys. Soc. B 70, 833-839 (1957).

It is found at Ibadan that during the daylight hours fE_s is lower on magnetically disturbed days than on quiet days. It is also found that on two or three occasions in each month a series of abnormally low values of fE_s occurs. An investigation of the behaviour of the horizontal and vertical components of the earth's field during these times reveals that there is a simultaneous decrease in the magnitude of the equatorial electrojet current which is in turn responsible for the large diurnal ranges in H and Z near the equator. The behaviour of the F2 layer parameters f_0F2, y_mF2 and h_mF2 during periods of low fE_s, shows that the F2 layer always becomes denser, lower and thinner during these periods. This indicates an immediate connection between the electrojet, the production of equatorial E_s and vertical drifts in the F2 layer.
A

SKINNER, N. J., J. Hope, and R. W. Wright. Horizontal drift measurements in the ionosphere near the equator. Nature 182, 1363-1365 (1958).

Measurements of the east-west drift components in the E and F layers at Ibadan by the spaced-receiver method show that these are towards the west during daytime, and towards the east at night, and in opposite phase to those found in temperate latitudes. These results are in agreement with Martyn's theory, although the magnitude of the westward drift in the F-layer (105 m/sec. at magnetic latitude 2-1/2°S) is smaller than predicted for a station situated directly under the equatorial electrojet. The amplitude pattern observed on the ground for both layers is found to be elongated in the direction of the magnetic meridian.
PA

SKINNER, N. J., and R. W. Wright. The reflection coefficient and fading characteristics of signals returned from the E_s layer at Ibadan. IN: Ionospheric Sporadic E (Smith, E. K., Jr., and S. Matsushita, eds., MacMillan Co., New York, 1962).

Some of the characteristics of echoes from the two principal daytime types of E_s at Ibadan have been investigated by means of vertical incidence pulse transmissions in the frequency range 4 to 8 Mc/s. For the equatorial q-type E_s it is found that the fraction of the incident power reflected back varies with frequency f approximately as $1/f^{9.4}$. The fading rates are of the order of 4 c/s and increase almost linearly with wave frequency. Spaced receiver experiments indicate that the irregularities in the diffraction pattern on the ground are elongated along the geomagnetic field lines

with scale sizes of about 20 metres and 300 metres in the east-west and north-south directions respectively. Blanketing E_s is observed only occasionally at Ibadan and it is found that its fading characteristics are very similar to those of the normal E layer with fading rates of about 0.8 c/s. The ground amplitude pattern has scale sizes of 60 metres and 500 metres transverse and parallel to the field lines respectively and the fading at midday is consistent with the picture that the irregularities in the ionosphere are moving westwards with a steady horizontal drift velocity of about 60 m/s superimposed upon a random velocity of 30 m/s. The amplitude distributions of the signals reflected or scattered from both types of E_s are predominantly of the Rayleigh type.

SKINNER, N. J., A. J. Lyon, and R. W. Wright. Ionospheric drift measurements in the equatorial region. Proc. International Conference on the Ionosphere, London, 1962, 301-309 (The Institute of Physics and the Physical Society, London, 1963).

The true E-W velocities of drift in the E and F regions on selected magnetically quiet and disturbed days, obtained from correlation analysis of the fading at two spaced receiving aerials, are examined and compared. In the F region, the drift is westward by day with a velocity of about 70 m sec^{-1} and eastward by night with velocities of about 90 m sec^{-1} on quiet days and 50 m sec^{-1} on disturbed days. The reversals of drift are rapid and occur about 0600 and 2000 hours. In the E region the drift velocities are about 55 m sec^{-1} during the day and directed towards the west.

The effect of random changes in the radio diffraction pattern as it moves across the ground has been assessed by considering the characteristic fading velocity, and it is found that drift velocities deduced by a simple 'time displacement' analysis would be about 35% too high on average, although the error would be considerably larger than this at certain times of the day.

Elongation of ionospheric irregularities in the D, E and F regions increases from about 1·5 in the D region to more than 10 in the F region.

The variation with magnetic latitude of the E-W drift velocity in the F region shows good agreement with the theory suggested by Martyn.

SMITH, E K., Jr., and R. W. Knecht. Some implications of slant Es. NBS Rept. 5503, National Bureau of Standards, Boulder, Colo. (23 July 1957).

The phenomenon of slant E_s occurs both in the Arctic and near the magnetic equator. This report is mainly on the arctic type. Three examples are seen in the ionograms in the report, representing different stages of the same event recorded at College, Alaska, on Feb. 27, 1955. The first and last records in this group are two hours apart. Illustrative graphs of the different observations are documented in the text.
MGA

SMITH, E. K., Jr. Worldwide occurrence of sporadic E. NBS Circular 582, National Bureau of Standards, Boulder, Colo. (1957).

Detailed analysis of Es on a worldwise basis, combining the results obtained from vertical incidence pulse measurements and from field strength measuremnts for v.h.f. oblique incidence propagation. Considerations are given to the structure of the Es region, classification of Es types, ionosonde scaling conventions and power-dependence of fEs, temporal and geographical variations, height of occurrence, frequency-dependence of occurrence and correlations with magnetic activity. Three major Es zones (Equatorial, Temperate ;and Auroral) are distinguished on the basis of the temporal Es characteristics, the Equatorial zone being recognized only on the daytime side of the earth. Possible energy sources of Es are considered, and it is concluded that they are terrestrial for Temperate zone Es, extra-terrestrial (solar corpuscles) for Auroral zone Es, and related to the equatorial electrojet for Equatorial zone Es.
PA

SMITH, E. K., Jr. Sporadic E observed on VHF oblique-incidence circuits. AGARDograph 34, 129-146 (Sept. 1958).

This paper is concerned with sporadic E as observed on VHF circuits operated by the National Bureau of Standards. The only circuit for which extensive analyses are available is the initial ionospheric scatter circuit running from Cedar Rapids, Iowa, to Sterling, Virginia, in the United States, and operating at 27.775 and 49.8 Mc/s with high gain rhombic antennas. During the last year, observations have also been made over three frequency yagi to yagi circuits (30, 50, and 74 Mc/s) and four frequency rhombic circuits (30, 40, 50, 74), all circuits having their transmitters in Long Branch, Illinois, and their receivers on Table Mesa, near Boulder, Colorado. Another series of circuits operating on 50 Mc/s extend from Guantanamo Bay, Cuba, down across the magnetic equator in South America. A companion circuit to this later series runs from the northern part of Luzon in the Philippines to Okinawa in the Ryukyu Islands.

Preliminary observations are presented for some of these circuits. A rather crude but simple method is shown by which it is possible to predict VHF field strength levels from vertical incidence data. Simultaneous fading rate measurements made on 30, 50 and 74 Mc/s over the Long Branch to Boulder path indicate that fading during sporadic E normally has a period of a few seconds. However it is not uncommon for fading on 30 Mc/s to be more rapid than on 50 Mc/s; 50 Mc/s to be more rapid than 74 Mc/s. Results such as these seem to point towards a mechanism where intense patches of ionization occur in the E region and reflections take place when plasma densities pertinent to the frequency and obliquity in question occur. When referred to the inverse distance level, signal strengths during periods of sporadic E propagation appear about 10 dB higher on 5 element yagi antennas than on high gain rhombics.
N

SMITH, E. K., Jr., and J. W. Finney. Pecularities of the ionosphere in the Far East: A report on IGY observations of sporadic E and F-region scatter. J. Geophys. Res. 65, 885-892, (March 1960).

This paper considers the results for the period October 1, 1957, to October 1, 1958, from the IGY 'VHF oblique-incidence sporadic-E measurements' program which operated circuits at 50 Mc/s in the Far East and the Caribbean. Sporadic E is found to be three to five times more frequent in the Far East than in the Caribbean for reflection coefficients of -20 to -80 db relative to inverse distance. Negligible dependence of magnetic activity is observed in either area, but diurnal and seasonal variations are more regular in the Far East. It is suggested that this longitudinal difference may be due either to the influence of the East Asiatic monsoon, perhaps through the mechanism proposed by Martyn, or to the difference in the relationship of magnetic dip to geographic latitude in these two areas.

A peculiar evening signal enhancement, referred to as the 'Far Eastern anomaly' or the 'evening signal anomaly,' appeared quite regularly in the Far East, and pulse-delay measurements indicate the probable source of the reflection to be the F region. The corresponding effect in the Caribbean is about 100 times less frequent, if it exists at all. The ^{n}F (layer tilt) reflection mechanism proposed by workers at Stanford does not appear too promising in this case, owing to the pulse broadening of the order of 1 millisecond which is normally encountered in the evening signal anomaly. A mechanism that would explain the structure of the observed signal involves reflection from field-aligned ionization similar to the mechanism invoked to explain the 'low-latitude auroral echoes' observed at Stanford.
A

SMITH, E. K., Jr., and J. W. Finney. Peculiarities of the ionosphere in the Far East: sporadic E and F region scatter. IN: Beynon, W. J. G., ed., Some Ionospheric Results Obtained During the I.G.Y., Proc. Symposium URSI/AGI Committee, Brussels, Sept. 1959, 182-192 (Elsevier Publishing Company, New York, 1960).

Through a study of ionosonde data from the world-wide network of stations and of miscellaneous oblique-incidence field-strength measurements made in Japan and the United States it was discovered shortly before the beginning of the I.G.Y. that sporadic E appears considerably more intense in the Far East than in similar latitudes in the Western Hemisphere. Comparisons of sporadic E data are very difficult unless made under identical conditions. Therefore an experiment was designed which consisted of recording transmission loss over two matched 50 Mc/s oblique-incidence circuits of approximately 800 miles in length, one in the Far East and the other in the Caribbean. The principal advantage of an oblique-incidence circuit over a vertical-incidence one at the equivalent frequency (about II Mc/s in this case) is that although the amount of sporadic E observed would be comparable, the effect of D region absorption in decibels at 50 Mc/s would be less than at II Mc/s by a factor of about 4.5.
A

SMITH, E. K., Jr. Report on the first international symposium of equatorial aeronomy, Peru, 18-27 September, 1962. IN: Semi-annual Report to Voice of America, NBS Rept. 7621, National Bureau of Standards, Boulder, Colo., 101 (July 1962).

The conference on Equatorial Aeronomy was held on September 18-27, 1962, near Huancayo, Peru. Attendance at the conference covered essentially two categories of people: the active workers in equatorial aeronomy (mostly magnetic and ionospheric aspects) and those from laboratories in South America who might well profit by the exposure to workers in equatorial aeronomy. See also Cohen for a brief statement on the symposium.
Excerpt

SMITH, W. B., and D. H. Pratt. Phase stability of HF signals over a 1600 km link. Paper presented to Committee III, URSI Fall Meeting, Austin, Texas 23 Oct. 1961.

Measurements of the phase stability of HF signals propagated over a 1600 kilometer link have been made using atomic cesium frequency standards at both terminals. By the transmission of short pulses it was possible to observe E- and F-layer reflections simultaneously; identification of the observed modes was accomplished with the aid of oblique ionograms. Selected pulses from among the several modes were recorded on magnetic tape in a format suitable as an input to a digital computer, with which the data analysis was performed. The results in the case of E-layer reflections show stabilities over ten-minute intervals approaching the nominal stability of the standards, and commensurate with reported results of VLF measurements. F-layer reflections recorded simultaneously show stabilities less typically by an order-of-magnitude.

A

SOMAYAJULU, Y. V. Oblique incidence pulse observation of the ionosphere near the maximum usable frequency. Current Sci. 21, 155-156 (1952).

Pulse transmission experiments at frequency 21.7 Mc/s over a distance of about 1500 km at Delhi indicate that Appleton's and Beynon's explanation of a parabolic region of the reflecting layer (F2) is correct since the sequence of observation was similar and particularly because a sudden increase in the signal intensity was clearly observed.

N

SOMAYAJULU, Y. V., B. Ramachandra Rao, and E. Bhagiratha Rao. Investigation of travelling disturbances in the ionosphere by continuous-wave radio. Nature 172, 818-820 (1953).

The first letter describes a simple method using continuous short-wave signals and oblique-incidence pulses from Madras recorded at Waltair, 640 km distant. A typical record indicates velocities of 200-400 m/s, larger and less uniform by day than by night. The second letter describes a similar method using two short-wave transmissions on close wave lengths.

N

SOMAYAJULU, Y. V. A study of the changes in the F-region during severe magnetic storms. Scientific Rept. 146, Contract AF 19(604)4563, Ionosphere Research Laboratory, Pennsylvania State University, University Park, Pa. (1 March 1961). AD-256 941.

A study is presented of the F-region changes associated with three severe magnetic storms during the IGY period. The h'-f data from Washington D.C., Panama, Talara and Huancayo Stations, which lie close to the 75 degree W meridian, are used and the corresponding N-h profiles are derived using Budden's method. The N-h profiles are studied in terms of: (1) Storm changes in the N sub m F and h (.9N sub m F), (2) The total electron content up to 200 km and between 200-300 km, and (3) The vertical drift velocities during storms. The storm changes in N sub m F and h (.9N sub m F) indicate that large height deviations of the order of 200 km may occur during severe storms. The vertical drift velocities during storms computed from the experimental N-h profile data reveal upward drifts. These drifts produced by the disturbance fields are found to be of the same order as the quiet day drifts. It is found that the total electron content up to 200 km is relatively unaffected by storms and that the electron content between 200-300 km is decreased at least during the first day of the storm in lower latitudes, by about 20-50%. The time sequence of the ionospheric events during storms is believed due to the hydromagnetic effects of the interaction between solar plasma and geomagnetic field.
A

SOMAYAJULU, Y. V. Ionospheric research. Some features of the F region electron density and height variations in the equatorial regions. Scientific Rept. 192, Contract AF 19(604)-4563, Pennsylvania State University, University Park, Pa. (1 Sept. 1963).

The average quiet day variations in maximum electron density (NmF) and h(0.9NmF) for the equatorial stations Talara and Huancayo are presented, derived from the true-height profiles for the five international quiet days for each of the IGY months. The results show that the forenoon and evening slopes of the Nm(t) curves, as well as the postsunset increase in the F-region heights have similar semiennual variations. This semiannual variation has a close correlation with the variation of the cosine of the noon solar zenith angle of the sun, indicating that electrodynamic drifts are important in producing the observed seasonal variation. Vertical drifts alone are inadequate to account for the large slopes in the Nm(t) curves: east-west drifts, such as those observed experimentally, can cause large variations in these slopes. The phenomenon of the postsunset increase in F-region heights, and its seasonal variation, is explained. It is concluded that, in the equatorial regions, the ionospheric electrostatic fields play a dominant part in causing the equatorial anomalies.
STAR

SOMAYAJULU, Y. V. Changes in the F region during magnetic storms. J. Geophys. Res. 68, 1899-1922 (1963).

The F-region changes associated with three severe magnetic storms during the IGY period are studied. The relevant h-f data from Washington (D.C.), Panama, Talara, and Huancayo, which lie approximately along the 75°W meridian, are converted to electron-density-true-height profiles. From the N-h profiles the storm changes in N_mF, $h(0.9N_mF)$, N_r, the total electron contents up to 200 and 300 km, and the thickness parameters $[h(0.9 N_mF)-h(0.5N_mF)]$ are determined and studied. The storm changes in N_mF and $h(0.9N_mF)$ indicate that large height variations of the order of 200 km may occur during severe storms. It is shown that the changes in N_mF and $h(0.9N_mF)$ during given storms could be separated into two parts: one due to polar ionospheric DS currents, and one (Dst) due to current systems well above the ionosphere. These have general features similar to those derived for averages of storms although several significant departures are observed. It is found that the total electron content up to 200 km is relatively unaffected by storms; N_mF, the electron content between 200 and 300 km, and the subpeak electron content are, in general, found to decrease during strong storms from middle latitudes to the equatorial region. The thickness of the F region is also found to increase after the SC during the first day of the storm. The DS part of the ionospheric storm effects is explainable by Martyn's drift theory. The Dst part can be explained as being due to an enhanced loss coefficient at relevant height levels. The increase in the loss coefficient is believed to be caused by ionospheric heating during storms as inferred from recent satellite drag data.
A

SOMAYAJULU, Y. V. Evidence on the horizontal diffusion of F-region ionization along the magnetic lines of force in equatorial latitudes. J. Geophys. Res. 69, 561-563 (1964).

Wright [1960] has reported that at Bogotá (dip 32°N) the F-region ionization density at night is greater than that in the regions nearer the dip equator. He suggests that horizontal diffusion of equatorial ionization along the earth's magnetic field lines could explain this feature. Recently Rao [1963], examining the f_0F_2 data for Léopoldville (dip 33°S) and the h'F data for Ibadan (dip 6°S), has found that during the period of sunspot maximum a postsunset increase in f_0F2 occurs in the transition zone (30°-40°) around 2100-2200 hours. He has also found that this phenomenon occurs about 2 hours after the postsunset rise in h'F2 occurs at Ibadan, which is in the same longitudinal zone, and he infers that horizontal diffusion is responsible for it. Rao's analysis is based only on the ionospheric data for the equinoctial months during the IGY. The purpose of

this note is to analyze this phenomenon in more detail and to present evidence that would lend support to the horizontal diffusion theory.

For this analysis the N_mF data for Panama (dip 39.2°N) and true height data for Talara (dip 13°N) for the IGY period on International Quiet Days are used. These stations lie approximately along the 75°W meridian.

From Figure 1, which shows the average diurnal variation of N_mF at Panama for various IGY months, it can be noted that during the equinoctial months a pronounced postsunset increase in the N_mF occurs around 2000-2100 hours, corroborating Rao's results. In Figure 2 are plotted the maximum value of N_mF in the interval 1800-2200 hours versus the month and the maximum value of $h(0.9N_mF)$ at Talara at the time of the minimum postsunset rise in height. It is seen that the postsunset increase in N_mF at Panama exhibits a seasonal dependence, has a maximum around the equinoxes, and is practically absent during the solstices. This seasonal behavior shows a very close correlation with the seasonal dependence of the postsunset rise in the heights at Talara. It is of interest to note that the maximum increase in N_mF at Panama occurs when the postsunset rise at Talara is maximum, whereas during the solstices, when the postsunset rise in the height at Talara is minimum (of the order of 30-40 km), the postsunset increase in N_mF at Panama is practically absent. Furthermore, this phenomenon occurs after the postsunset rise in height at Talara; the time delay varies from 1/2 to 1 1/2 hours. These observations are in agreement with Rao's results except that he finds a time delay of the order of 2 hours for stations in the African zone.

Mitra [1946] suggested that the equatorial anomaly, i.e., the existence of a belt of low noontime f_0F2 values centered on the magnetic equator, might be explained by supposing that the ionization in the equatorial regions diffuses horizontally along the geomagnetic lines of force to higher latitudes. Martyn [1955] and Duncan [1960] have developed this theory further by including the effects due to electrodynamical drifts. These drifts lift the ionization to greater heights, from which they subsequently drop down the field lines. Duncan estimates that the equilibrium conditions would be reached about 2 hours after the rise in the equatorial ionosphere.

From the observational evidence, (1) that the postsunset rise in heights occurs only during years of maximum sunspot activity [Appleton, 1960; Rao, 1963], (2) that it has a seasonal dependence [Somayajulu, 1963], and (3) that the postsunset increase in N_mF also occurs during the high sunspot activity and has a seasonal dependence closely correlated with the postsunset rise in the equatorial regions, we establish that the postsunset rise of the F region in equatorial regions acts as a causative mechanism for the postsunset increase in N_mF in the transition zones. Thus the observational evidence presented here may be taken to lend strong support to the Mitra-Martyn diffusion theory.

Ferraro [1961], Lyon [1962], Gliddon and Kendall [1962], and Goldberg and Schmerling [1963] discussed, from a theoretical viewpoint, the phenomenon of diffusion of ionization along the magnetic lines of force and investigated the quantitative effect on the equilibrium distribution in the equatorial belt. It appears from the work of Goldberg and Schmerling that in the height range of 250-650 km horizontal diffusion significantly modifies the equilibrium distribution of ionization, causing a belt of low values of N_mF to appear. For a considerable increase in N_mF to occur toward the edge of the equatorial belt it appears to be necessary that the ionospheric region close to the equator be lifted above about 500 km. This will probably explain the observation that at Talara, where the initial heights are of the order of 450-475 km, the postsunset rise in height must exceed about 50 km for an increase in N_mF to appear at Panama.
Excerpt

SOMAYAJULU, Y. V. Some features of the F-region electron-density and height variations in the equatorial regions. J. Geophys. Res. 69, 1329-1339 (1 April 1964).

This paper presents the average quiet day variations in N_mF and h (.9NmF) for the equatorial stations Talara and Huancayo, derived from the true-height profiles for the 5 international quiet days for each of the IGY months. The results show that the forenoon and evening slopes of the Nm(t) curves, as well as the postsunset increases in the F-region heights, have similar semiannual variations. It is established that this semiannual variation has a close correlation with the variation of the cosine of the noon solar zenith angle of the sun, indicating that electrodynamic drifts are important in producing the observed seasonal variation. It is shown that vertical drifts alone are inadequate to account for the large slopes in the Nm(t) curves. It is further shown that east-west drifts, such as those observed experimentally, can cause large variations in these slopes. A seasonal variation of the wind pattern may account for the observed seasonal variation. On this model the phenomena of the postsunset increase in F-region heights, and its seasonal variation, are explained. It is indicated that several other equatorial phenomena such as spread F and flutter fading can be explained on this basis. It is concluded that, in the equatorial regions, the ionospheric electrostatic fields play a dominant part in causing the equatorial 'anomalies.'
A

SOUTHWORTH, M. P. Night-time equatorial propagation at 50 Mc/s: first results from an IGY amateur observing program. J. Geophys. Res. 65, 601-607 (1960).

During IGY the American Radio Relay League collected radio amateur reports of 50- and 144-Mc/s ionospheric propagation, evaluated them, and transcribed them onto punched cards. Analysis of 50-Mc/s equatorial intercepts, begun this summer at Stanford University, has revealed three apparently related types of nocturnal, low-latitude propagation: (1) long-range transequatorial, as first noticed by amateurs in 1947; (2) medium-range between stations making transequatorial contacts and stations near the magnetic equator; (3) short-range, similar to sporadic E but occurring regularly with the first two types. Where ever they appear these modes are present almost nightly during certain months, and evening propagation of frequencies up to 1.5 times the maximum daylight MUF is not uncommon. Comparison of transequatorial results in the Americas and the Far East has shown that seasonal behavior is not same at all meridians. Pronounced negative correlation with magnetic activity is a world-wide feature, however, which suggests a direct relation to equatorial spread F. Quantitative professional data at the frequencies of interest are rather rare, but comparisons with Dueno's backscatter soundings made at the University of Puerto Rico indicate that the 20- and 40-Mc/s transequatorial propagation seen there is not the same as what amateurs experience on 50 to 75 Mc/s.
MGA
Similar material appeared in:

SOUTHWORTH, M. P. Night-time radio propagation in equatorial regions: first results of the IGY amateur radio research program. Trans. Am. Geophys. Union 41, 693-698 (1960).

SOUTHWORTH, M. P. Night-time equatorial propagation at 50 Mc/s, final results from an IGY amateur observing program. Final Rept. 31, Contract AF 19(604)-5235, Electronics Laboratory, Stanford University, Stanford, Calif. (31 May 1960).

During the IGY the American Radio Relay League collected radio amateur reports of 50 and 144 Mc/s ionospheric propagation, evaluated and transcribed them onto punched cards. Additional reports through March 1960 have been collected from 104 selected amateurs by the Stanford Radioscience Lab. and turned into 10,794 punched cards. These and the IGY amateur data relating to 50 Mc/s low-lat propagation and trans-equatorial scatter have been studied during the program described in this report. Results in summary trans-equatorial scatter (TE) causes VHF signals to propagate over 5000-10,000 km trans-equatorial paths

during the evening hours. Diurnal and seasonal plots are presented for typical paths, and it is concluded that there are actually two kinds of evening trans-equatorial propagation. The first type provides steady signals and is best between 1800 and 1900 local time. The second gives signals a deep flutter fade and maximizes at 2000-2200 local time. Both types occur most often during the equinoxes. TE is shown to correlate negatively with magnetic activity and positively with spread F and with the height of the F layer on the equator at 1900 local time. Either magnetic or h'F data for this hour can be used to predict spread F and TE a few hours later, especially at the equinoxes. The report is well supplied with graphs, charts, and tables representing the collected, computed and reduced data.
MGA

SPITZER, L., Jr. Physics of Fully Ionized Gases (Interscience Publishers, Inc., New York (1956).

Both in gaseous electronics and in theoretical astrophysics there is a growing interest in gases which are almost completely ionized. Although, of course, ionization is never entirely complete, under some conditions the fraction of neutral atoms present may be less than a few percent, and such atoms may therefore be neglected in discussing most of the physical properties of the gas. Moreover, in the case of hydrogen, which is overwhelmingly the most abundant element in the stars and in space, atoms which are ionized are also stripped. Helium, the next most abundant nucleus, is mostly stripped of its two orbital electrons inside the sun and in the solar corona. Even in a laboratory gas certain observed phenomena, such as plasma oscillations, are independent both of the presence of neutral particles and of the presence of bound electrons in the ionized atoms. Thus for many purposes it is useful to analyze theoretically the behaviour of a gas composed entirely of electrons and bare nuclei.

Such a gas has the advantage of considerable simplicity in certain respects. Most quantum-mechanical effects can usually be ignored, except for a relatively weak interaction with the radiation field. Most of the phenomena important in normal gaseous electronics disappear; electron attachment, dissociative recombination, excitation and deexcitation of atoms and molecules, electrical breakdown, etc., do not occur in a fully ionized gas. Since a solid surface would reduce the ionization, any such surface must lie far from the regions being considered, and hence the complicated processes occurring at a solid surface may be ignored. Likewise, the encounters between charged particles become in principle much simpler,

as inverse-square forces are more precisely calculable than the complicated interactions of systems containing bound electrons.

The problems encountered in analyzing a fully ionized gas are of several types. Although the basic physical processes are simpler than in an ordinary gas the motions are more complex, since these are coupled to the electromagnetic field. In the presence of a strong magnetic field this coupling between dynamics and the electromagnetic field gives rise to novel phenomena, first explored by Alfvén, which are included under the general heading of magneto-hydrodynamics, or, more simply, hydromagnetics. The latter term, suggested by Cowling, will be employed here. Even in the absence of a magnetic field the electrical properties of a completely ionized gas permit complicated motions, which involve electrostatic restoring forces, and which have no parallel in ordinary gases. Finally, the theory of collisions between particles, in so far as these determine the transport coefficients-electrical and thermal conductivity, viscosity, etc. — and the time of relaxation—the time required to establish an equilibrium velocity distribution—may be approached with a new viewpoint, because of the long-range character of the inverse-square forces involved.

Considerable progress has been made in these fields during the last few years, especially as a result of the work by Alfvén, Cowling, and Schlüter. No general but simple introduction to the subject now exists, and any one wishing to familiarize himself with this area must consult mostly original papers in a variety of journals. The purpose of the present tract is to provide such an introduction, designed for students at the graduate level.

The subject matter is restricted to those topics that may serve to give a theoretical understanding of the subject. Although some observational data are available on certain phases of the subject, as, for example, electromagnetic and electrostatic waves in plasmas, this material has been entirely excluded. To have added a detailed comparison with observations would have meant a considerable increase in the length and scope of this tract.

The book is designed for those who have had an introductory course in theoretical physics, but are otherwise unacquainted with the detailed kinetic theory of gases. For example, a knowledge of Maxwell's equations is assumed, and likewise a familiarity with the elements of vector analysis, such as is provided in the introductory chapter of Page's Introduction to Theoretical Physics. The bibliography is by no means complete, but it includes some of the basic papers in each area. It is hoped those who may work in the general field of fully ionized gases will find the references a useful introduction to a new and rapidly growing area of physics.

A

SPREITER, J. R., and B. R. Briggs. Theory of electrostatic fields in ionosphere at polar and middle geomagnetic latitudes. J. Geophys. Res. 66, 1731-1744 (1961).

Analysis is developed for electrostatic field of arbitrary horizontal scale in horizontally stratified, partially ionized gas subject to imposed magnetic field in polar and middle geomagnetic latitudes; attenuation is much less than which would be experienced in homogenous medium; relatively small changes in ionospheric conditions can result in substantial changes in attenuation of electric field with height.
EI

SPREITER, J. R., and B. R. Briggs. Theory of electrostatic fields in the ionosphere at equatorial latitudes. J. Geophys. Res. 66, 2345-2354 (1961).

The properties of the elongated electrostatic fields that are required to provide the coupling mechanism in the dynamo-motor concept of the E and F regions of the ionosphere are examined theoretically for the conditions that prevail in equatorial latitudes. The analysis is developed for an electrostatic field of arbitrary horizontal scale in a horizontally stratified partly ionized gas subject to an imposed magnetic field having the form of a parabolic arch over the equator. The anisotropic character and continuous variation with height of the conductivity are retained throughout, and numerical solutions are determined for the attenuation of the electric field with distance along the field line.

The results are similar qualitatively to those found previously upon analysis of the corresponding problem for middle latitudes, but the attenuation of the electrostatic field with height is considerably greater. It develops, in particular, that the coupling between E and F regions is very small for fields having horizontal wavelengths of a few kilometers. It follows that the dynamo-motor concept could not be used to account for the presence of irregularities of this scale. On the other hand, it is found that almost all the attenuation occurs at heights near that of the E region. If an electrostatic field having a horizontal wavelength of a few kilometers could be produced at heights of, say 200 km or greater, it follows that it would be very elongated and extend with little change in amplitude from hemisphere to hemisphere. The results also indicate that effective coupling could be achieved for fields having horizontal wavelengths of the order of tens of kilometers, but the assumptions introduced to simplify the analysis may impair the quantitative reliability of the results for fields of this scale.
A

SPREITER, J. R., and A. Y. Alksne. On the effect of a ring current on the terminal shape of the geomagnetic field. J. Geophys. Res. 67, 2193-2205 (June 1962).

The interaction between a neutral stream of ionized solar corpuscles and the combined magnetic fields of a 3-dimensional dipole and an equatorial ring current is investigated. It is assumed that the stream is confined to the exterior and the magnetic field to the interior of a hollow, the boundary of which is defined by a thin current sheath. The shape of the hollow is sought by application of an approximate method of solution. Results are presented for the traces of the boundary in the equatorial plane and the meridian plane containing the dipole axis and the Sun-Earth line for the case in which the dipole axis is normal to the Sun-Earth line. It is found that the presence of the ring current has the effect of greatly increasing the size, as well as altering the form, of the region bounded by the current sheath. The calculated results are, moreover, in essential agreement with the observations when representative values are inserted for the properties of the ring current and the solar corpuscular stream.
MGA-

SRINIVASAMURTHY, B. The diurnal variation of sizes of sudden commencements and impulses in the Kodaikanal magnetograms. Indian J. Met. Geophys. 11, 64-68 (1960).

Combined data of sudden commencements (SCs) and sudden impulses (SIs) recorded at Kodaikanal (geomagnetic latitude 0.6°N) during the period 1949-57 have been analysed in order to study the relationship between the diurnal variation (DV) in the amplitudes of the impulses and the DV in the horizontal component of the earth's magnetic field (the Sq variation in H). There is a statistically significant daytime enhancement in SC sizes similar to the enhancement in Sq variation. Furthermore, this enhancement is larger on days with larger Sq variation than on days with smaller Sq variation. These results confirm those obtained by Forbush and Vestine (1955) at Huancayo, another station near the geomagnetic equator.
A

STACEY, F. D., and P. Westcott. Possibility of a 26-or 27-month periodicity in the equatorial geomagnetic field and its correlation with stratospheric winds. Nature 196, 730-732 (1962).

The existence of an irregular fluctuation of period about 2 years is inferred from a plot of monthly mean values of the horizontal component of the earth's magnetic field on quiet days at Huancayo, Alibag and Apia. The results of spectral analysis of the Alibag data show a broad peak at 26 months, and for Apia at 27 months for two subdivisions of the data. The Huancayo material gives only weak and ill-defined peaks. These results are taken as evidence that the 26-month recurrence interval in stratospheric winds over equatorial regions may extend into the ionosphere: but values of midday critical frequencies and virtual heights of the E layer at Singapore, Ibadan and Slough provide little support for this idea. It is concluded that the oscillatory mechanism must be a property of the stratosphere.

PA

STACK-FORSYTH, E. F. An experimental study of the propagation of 10 cm radio waves over a short non-optical sea path. Proc. IEE 102B, 231-236 (1955).

A series of tests in microwave propagation over a sea path of length 1.14 x the optical horizon was conducted off the coast of Natal during the winter months, April-August, 1953, to study the effect upon signal strength of variations in the structure of the refractive index profile of the atmosphere in the first few hundred feet above sea level. The radio equipment operated at a wavelength of 10 cm, and vertical polarization was used throughout the tests.

A

STILTNER, E. Equatorial flutter-fading observations. IN: Semi-annual Report to Voice of America, NBS Rept. 7696, National Bureau of Standards, Boulder, Colo., 155 (July 1963).

This paper presents the results of autocorrelation, power spectrum, and probability distribution claculations upon signal strength records

obtai... in an east-west path close to the geomagnetic equator during flutter-fading events. The autocorrelation curves show a significant oscillation about the zero axis at large time lags. The power spectra show that significant power is present at frequencies up to about five cycles per second and persists throughout the course of a flutter-fade event. Last, a Rayleigh distribution of amplitudes is observed throughout the course of an event.

A

STILTNER, E. Modulation tests for a 1160 km path along the magnetic equator. IN: Semi-annual Report to Voice of America, NBS Rept. 7696, National Bureau of Standards, Boulder, Colo., 205 (July 1963).

This paper presents some of the results of an investigation of radio propagation in the equatorial ionosphere. See "A Study of Radio Propagation Characteristics in the Equatorial Ionosphere" by A. F. Barghausen and D. A. Lillie, elsewhere in this report for further description of the program.

During the recent field studies of radio wave propagation at equatorial latitudes, some modulation experiments were planned to determine ionospheric transmission characteristics within an audio passband.

This note describes the results obtained from a series of four exposures made during an early morning test run. Equipmental failure precluded obtaining any further data at the time.

This experiment was conducted as follows, using the equipment described in further detail in a previous report. The 10.1018 Mc transmitter at Monrovia, Liberia was amplitude modulated with a scanning waveform of a one millisecond period. The equipment used for generating the scanning waveform and driving the transmitter included a Tektronix 162 waveform generator, and a Heathkit audio amplifier to drive the low-impedance modulation input on a Hewlett-Packard 606 RF generator tuned to 10.1018 Mc.

At the receiver, at Accra, Ghana the diode output from the second detector on the SP600 receiver was connected directly to the dc input on a Hewlett-Packard oscilloscope. Receiver bandwidth was set to maximum during the modulation tests. Photographs were taken of the oscilloscope trace at the noted times.

A harmonic expansion was calculated for each of the photographs using the procedure described in Appendix I, and ratios were obtain of the observed amplitudes of each harmonic to the theoretic amplitudes which were assumed transmitted. The photographs and the resultant transfer curves are presented in figures 1 to 4.

The immediate features of these curves are the large amplitude changes which take place within the space of a few minutes for a given

frequency and the irregular variation of the curve over the frequency range of 1 to 10 kc, suggesting that transmission characteristics vary independently for a frequency difference of a few kc.

This conclusion is of interest in view of the fact that these tests were made during the morning when the propagation between Monrovia and Accra was stable. The Doppler records show steady E and F level reflections so an interference pattern between the two is possible.

However, variations induced by the equipment cannot be ruled out for these data. The main conclusion from this preliminary test should be that the experiment should be repeated, both during quiet and disturbed periods with some further checks to make sure that the ionosphere is responsible for what is observed. For example, care should be taken that the signal generator and transmitter are not driven past linear operation. A receiver and oscilloscope near the transmitter to receive the ground wave should assist in this check. The receiver should be operated on AGC to ensure that overloading of any receiver circuits does not occur. A high-speed chart recorder connected to the AGC during runs would be useful for later interpretations of the results.

Excerpt

STRANZ, D. Solar activity and the altitude of the tropopause near the equator. J. Atmos. Terrest. Phys. 16, 180-182 (1959).

The study of the behaviour of the tropopause at Leopoldville (ϕ = 4.4°S, λ = 15.0°E) during the period of radio soundings from June 1953 to December 1958 reveals a very good correlation between its pressure level or altitude and the Zurich sunspot number R of solar activity. It can be seen from Fig. 1 that the running means over 13 months of the height of the tropopause, being at 15.3 km in December 1953, begin to rise at the end of 1955 up to 16.4 km, reached at the end of 1957. This increase coincides with an increase of the running means over 13 months of sunspot number from R_{13} = 70 to R_{13} = 200 by the end of 1957. No regard has yet been given to a possible phase lag between the two phenomena. An investigation of the temperature at the tropopause level shows its constancy throughout the 5 years from sunspot minimum to maximum, so that the average temperature of -79.8°C for the 5 years moves up from 15.2 to 16.4 km height. It is obvious that this displacement of the important discontinuity between the troposphere and the stratosphere, in close relation with the solar activity, will influence the vertical distribution of atmospheric temperature and, as a consequence, the weather phenomena too. We feel this is the first time that such a

close correlation between sunspot number and the behaviour of the low atmosphere has been shown. Hitherto the influence of solar activity on tropospheric phenomena was supposed to be doubtful or negligible, and on the stratosphere or ozonosphere it was assumed to exist, but was not yet clearly shown. The change of the temperature gradient in the uppermost troposphere from 1954 to 1958 reveals interesting effects on weather, one of which will be dealt with here. The mean vertical temperature gradients between 150 mb level and the tropopause for each year from 1953 (only June to December 1953 are available) and 1954 to 1958 are shown in Fig. 2 together with the total precipitation of the corresponding years at Leopoldville airport. The use of an average of railfall upon a greater area would be more reasonable and will be tried later. The total precipitation is, in general, lower when the temperature decreases less with height, and this is the case in the years of high sunspot number due to the elevated tropopause. There is still a high random effect in the precipitation of a single station. The relative humidity, however, at the highest level regularly measured, i.e. at 300 mb, shows still much better correlation (Fig. 3). Water vapour in the atmosphere is transported upward from the ground, the amount being the greater, the greater the temperature gradient. This happens at sunspot minimum (1954-1955) while at sunspot maximum (1957-1958) the mean relative humidity is considerably reduced. It remains to be studied if this phenomenon is due to an actual deficit of water vapour or is a consequence of increased temperatue at 300 mb.

Finally a plot of a running means over 3 months of the differences for each month, between the mean maximum height of tropopause at sunspot maximum and the mean minimum height at sunspot minimum shows a definitely greater amplitude of displacement of this surface during the second half of the year. For this period the amplitude is 1800 gdm (or 12%) against 1000 gdm (or 7%) for the first half of the year. This change in amplitude due to the solar activity upon the altitude of the tropopause is in fairly good agreement with the yearly variation of total amount of ozone above Leopoldville (available for 1958 and assumed similar for the other years). Its highest value appears in September, too, and its lowest in April/May. This result (Fig. 4) may give a hint towards a probable mechanism involving the solar activity upon the ozone layer with further transfer downward to the tropopause. A detailed investigation of other phenomena will be published later elsewhere.
Excerpt.

STROUD, W. G., and W. Nordberg. Seasonal, latitudinal and diurnal variations in the upper atmosphere. NASA, Washington, D. C. (April 1961).

Over the past decade some 30 vertical sounding rockets carrying the grenade experiment have been fired in the Arctic, in the middle latitudes, and in the equatorial Pacific. The temperatures and winds up to 90 km have been measured in the various seasons of the year. The majority of the measurements were made as part of the IGY program, the most recent data being the IGY Guam firings. Although there were individual variations of significance at the three different latitudes, the outstanding feature of the wind data is the uniformity with latitude of the seasonal variations. Over the latitude-altitude ranges sampled, the winds are strong and from the west during the winter months; weak and from the east during the summer months. The measurements made at the seasonal turnovers particularly reveal the nature of the circulation pattern.
JPL

SUCHY, K., and F. Vila. The magnetic field in the F2 layer at Dakar. Ann. Geophys. 12, 277-282 (1956). (In French.)

The gyrofrequency, fH, at the level of the F2 layer maximum at Dakar was determined from values of the magneto-ionic separation of the critical frequencies. The variation of fH with height agrees fairly well with that expected for the magnetic field of a dipole, and the diurnal and annual variations at a fixed height may also be found. It was found that the deviation of the magneto-ionic components in the magnetic meridian could be neglected for the present case of monthly median values for a station of low dip-angle.
A

SUGUIRA, M. The solar diurnal variation in the amplitude of sudden commencements of magnetic storms at the geomagnetic equator. J. Geophys. Res. 58, 556-559 (1953).

The question of whether or not the sudden commencement of magnetic storms is abnormally large at the geomagnetic equator was studied by

comparing SC's at Huancayo to those at Cheltenham. It was found that the sudden commencement is enhanced during sunlit hours at Huancayo, which is located near the geomagnetic equator.

The present statistics are based on 183 SC's in the period 1922 to 1946. SC's were chosen only when they took the typical form at all of three stations, Huancayo, Watheroo, and Cheltenham, so that "crochets" were excluded from the statistics. It is not likely from studies on Sq that changes in magnetic field of crochets manifest themselves as rises in the horizontal component of all of the three stations at any hour of local time. In Figure 1 are plotted the mean of the ratios of amplitudes of the horizontal component of SC's for Huancayo to those for Cheltenham (the curve A) and the number of SC's (the curve B) against 75th Meridian Mean Time. Cheltenham was chosen because the station is located nearly on the same meridian as Huancayo, thus eliminating the factor coming from the relative positions to the sun of the two stations for which the ratio is taken.

The curve A clearly shows that there exists a solar diurnal variation in the sudden commencement at Huancayo. The ratio starts increasing in the morning, reaches as high as 5 or 6 between 08^h and 13^h, with a maximum around 11^h, and decreases towards the evening; it remains constant throughout the night, the ratio being approximately 1. Thus, as in the case of the solar daily variation, the sudden commencement field is augmented during sunlit hours. This suggests that the immediate source of the main portion of SC which occurs during sunlit hours at the geomagnetic equator is within the upper atmosphere of the earth.

The frequency of occurrence of SC's as shown by the curve B well agrees with Newton's result on Greenwich data. That is, there is a minimum centered around 08^h, and there are afternoon and night maxima with a break by a secondary minimum at about 18^h. It might be that the frequency of SC's depends upon the local time, not upon the universal time; or, rather it should be stated, in view of the world-wide nature of SC's, that this frequency curve represents the probability that SC's are of the "typical" form.

One might question* whether the diurnal variation of the above ratio is due to abnormally small SC's at Cheltenham during the daytime instead of SC's at Huancayo being so large. Although quantitative investigation of this point has not yet been made, it was clear to the writer by inspection of curves that this effect is due mainly to an enhancement of the sudden commencement at Huancayo. This is further confirmed by the fact that the same ratio of SC's at Huancayo to those at Watheroo is also large during sunlit hours. The details of the results of the present study will be published later.

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*This question was raised by Prof. S. Chapman, with whom the author had discussions at Ann Arbor, Michigan.

SUKHIA, D. E. An analytical method of obtaining received input voltages, required input voltages, LUFS and MUFS. Project 536, U. S. Army Signal Radio Propagation Agency, Ft. Monmouth, N. J. (Sept. 1958). Revised by G. E. Krause, L. C. Kelley, and S. E. Probst (May 1960).

This report presents the step-by-step analytical method used in predicting receiver input voltages, required input voltages, Lowest Useful High Frequencies, and Maximum Useable Frequencies. It was originally written as an informal document for a twofold purpose: (1) background for training of Agency personnel, and (2) as a first approach to the detailed understanding required by personnel who want to reduce these techniques to electronic computer programs. It has received only cursory editing and some major needed revision has only been mentioned in the Appendices. However, considerable interest has been expressed in this document and the decision to publish it has resulted. Particular attention is invited to Section III Summary Remarks on page 67.
A

SURYANARAYANA, R. K. Effect of radio fade-out on the F2-layer. J. Atmos. Terrest. Phys. 24, 57-64 (Jan. 1962).

The effect of radio fade-out on the maximum ionization density of the F2-layer is investigated by comparing the f_0F2 on the fade-out day with that on control days. The daily variations of the deviation Δf_0F2, of the fade-out day f_0F2 from the mean, has been studied for twelve fade-outs which occurred during the summer season in 1957, 1958 and 1959 over fairly wide latitudes ranging from the geomagnetic equator to 35°N. The variation in Δf_0F2 is observed to show a phase reversal at about 14°N geomagnetic latitude, during the post fade-out period.
MGA

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TANTRY, B. A. P., and S. R. Khastgir. Studies in fading of medium-wave radio signals. Indian J. Phys. 25, 27-32 (1951).

In the present investigation, intensity variations of the down-coming waves of medium radio frequencies from Delhi, Dacca, Lahore and Vijayawada Broadcasting stations as received at Banaras were studied in the evening and early night hours, there being no ground waves from these distant stations at the receiving point. Medium-wave signals from Lucknow, Patna and Allahabad Radio Stations were also received at Banaras and their intensity variations investigated.

The observations were made with a straight receiver having a suitable galvanometer in the balanced anode circuit of the detector valve. In most cases visual observations of the galvanometer deflections due to the varying intensities of the signals were made. In a few cases only the galvanometer deflections were recorded photographically on a rotating drum system.

The following types of fading patterns were observed:

(i) Periodic or quasi-periodic fading of slow and quick periods.

(ii) Random fading.

Regarding the observed periodic or quasi-periodic fading, there were two distinct orders of periodicity. The 'slow' periodicity has been attributed to the interference of the ordinary and extraordinary components of the wave in the ionosphere as described by Appleton and Beynon (1947). The comparatively 'quick' periodicity, which was also frequently observed, has been considered as due to the vertical movement of the ionospheric layer which usually takes place in the early morning or in the evening or early night hours. The Döppler-beat interpretation of this type of periodic fading is outlined and the expressions for the periodicity given.

The vertical velocity of the ionospheric layer, as computed from the Döppler-beat consideration of the so-called 'quick' periodicity, was found to be of the order of 35 metres/sec. during the evening or early night hours.

With regard to random fading observed with signals from distant stations, the analysis showed that the actual distribution curve did not agree with the Rayleigh's formula for random scattering. Rayleigh's formula is applicable to one downcoming wave only. With longer distances the existence of a number of waves following slightly different paths in the ionosphere may partly explain the discrepancy between the observed results and those computed from Rayleigh's formula. For more distant stations, more than one peak in the observed intensity distribution curve were observed. This must be due to the simultaneous single and double reflections from the E-layer.

TANTRY, B. A. P., and R. S. Srivastava. Waveforms of atmospherics. Proc. Nat. Inst. Sci. Ind. 24A, 217-225 (1958).

More than one thousand useful waveforms of atmospherics were recorded at Banaras during 1952-55 by the automatic atmospherics-waveform recorder constructed in the laboratory. A classification of the observed waveforms has been made and interpretations given in the paper. Besides the known types of waveforms which were already recorded by the previous investigators, the oscillographic records showed evidence of 'stepped' pulses from the leader of one lighting discharge of near origin, superimposed on the waveform due to a different lightning discharge. A few oscillograms also revealed a long train of sinusoidal oscillations of nearly constant frequency. A large number of oscillograms was attributed to cloud-to-cloud discharges. The observations regarding discharges within the cloud are reported elsewhere.

THIRUVENGADATHAN, A. Diurnal variation of horizontal magnetic force at Kodaikanal. Indian J. Met. Geophys. 5, 267-271 (1954).

The diurnal variation of horizontal force at Kodaikanal on each of the international quiet days during the summer solstices of the years 1949-1951 is subjected to harmonic analysis. The harmonic coefficients of the same period are plotted on a harmonic dial. In the case of a strictly persistent periodicity, affected only by random errors, the probable error figure will be a circle. For the 24-hourly wave that probable error figure is found to be an ellipse having the ratio of the axes, 1.86. The direction of the major axis indicates that the amplitude varies much more than the phase. An attempt is made to find out whether this large variation in amplitude can be accounted for by regular causes like degree of disturbance, variation of sunspot number etc. Sunspot number accounts only to a small extent for this large variation of the amplitude. The variability is mostly fortuitous. It is also noticed that as the value of the first harmonic coefficient decreases, the corresponding decrease in the second harmonic coefficient is less and the second component may even be larger than the first when the latter is very small.

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THOMAS, J. A., and A. C. Svenson. Lunar tide in sporadic E at Brisbane. Austral. J. Phys. 8, 554-556 (1955).

Accurate measurements have been made at Brisbane of the virtual height of reflection of radio echoes from the E region of the ionosphere, using a pulse transmitter operating at 2.28 Mc/s. The recordings were made by using a cathode-ray tube displaying echoes received from virtual heights between 80 and 150 km; black-out modulation of the cathode-ray tube trace was employed so that echoes appeared as gaps in the trace. To avoid the broadening of the gap with increase of echo signal strength, an automatic gain control was used, which kept the peak output within the time interval corresponding to 80-150 km at a fixed level. The gap width then remained fairly constant (about 18 km), and the recorded height showed no dependence on (input) signal strength. A stable triggered oscillator was used to produce height marks at 10 km intervals every 6 min on the cathode-ray display. The oscillator was started at full amplitude by a triggering wave synchronized with the transmitter modulation pulse; there was a constant delay of 0.[illegible] km.

THOMAS, J. A. Sporadic E at Brisbane. Austral. J. Phys. 9, 228-246 (1956).

Further data are presented in support of McNicol and Gipps's classification of two types of sporadic E at Brisbane (lat. 27.5°S.), namely, sequential type (E_{ss}) and constant-height type (E_{sc}).

Information is given on the occurrence, critical and blanketing frequencies, reflection coefficients, range spreading, vertical movements, and lateral extent of E_s patches.

No correlation is found with sunspot cycle, meteor occurrence, or thunderstorm activity. Scattering from a turbulent medium is not responsible for E_{sc} at Brisbane. Tidal movement is regarded as the most likely cause of both types of E_s.

A method of obtaining information about D region absorption is briefly discussed.

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THOMAS, J. A., and M. [illegible] Burke. Motion in the night-time E_s region at Brisbane. Austral. J. Phys. 9, [illegible]-453 (1956).

An analysis is made of night-time motion in the E_s region, as determined from a study of radio echoes at 2.28 Mc/s. Night-time E_s usually consists of moving clouds of ionization of lateral extent ~10 km; these clouds may be either isolated or close-packed to form layers of ionization. There is evidence that the clouds are sometimes elongated in a direction different from their direction of travel.

Good correlation is found between velocities of E_s movement as determined by fading analysis (Mitra 1949) and direction-finding techniques. Speeds of movement are grouped about 70 m/sec, and the winds are predominantly towards the north.

THOMAS, J. A., and E. K. Smith. A survey of the present knowledge of sporadic-E ionization. J. Atmos. Terrest. Phys. 13, 295-314 (1959).

In the following sections we discuss briefly the various techniques available and what information can be gained from their use. This is followed by the classification of E_s into various zones and types, and the next section contains the main bulk of the known information in tabular form. The final section deals briefly with some general theoretical considerations and makes some tentative recommendations. A bibliography is included.
A

THOMAS, J. A., and R. W. E. McNicol. A highly directional rotating array for the observation of field-aligned irregularities. Scientific Rept. 1, Contract AF (500)9, AD-252 605; AFCRL TN 60-119. University of Queensland, Australia (Sept. 1960).

The need for a highly directive rotating array is briefly discussed and the factors determining the over-all array design are brought forward. Within the limits imposed by economy, various types of array are analyzed, the choice finally residing in 4 Yagi aerials at a spacing of 1.1 wavelengths. Suitable methods have been devised for feeding each Yagi with the appropriate current determined according to a Dolph-Tchebyscheff analysis. Using a T-R switch, the effective total beam width at 16 mc is 8 degrees. Aerial test patterns, and records of echoes from field-aligned ionisation are given.
DDC

THOMAS, J. A. Trans-equatorial backscatter observations of magnetically controlled ionization. Nature 191, 792 (1961).

Comparison of the range-azimuth records obtained with a rotating backscatter equipment at Brisbane operating on a frequency of 16 Mc/s with the parallel of magnetic latitude 20°N shows that the echoes generally lie close to this line. Echo ranges vary from 6000 to 12000 km.
PA

THOMAS, J. A., and R. W. E McNicol. Instrumentation for the observation of field-aligned F region irregularities and transequatorial radio propagation. Scientific Rept. 5, Contract AF 64(500)9, Queensland University, Australia (Feb. 1962). AD-286 377; AFCRL 62-305.

A brief description is given of the general facilities available at the Field Station and this is followed by a more detailed analysis of certain specialised equipment developed during the present Contract. The main units discussed are: (1) a 16 Mc/s rotatable back-scatter sounder; (2) a 55 Mc/s rotatable back-scatter sounder; and (3) a 15-30 Mc/s rotatable back-scatter sounder. Information is also given regarding the methods used to obtain amplitude, polarisation, phase-path, and angle-of-arrival measurements of back-scatter echoes, and of scintillation data from satellite radio signals.
DDC

THOMAS, J. A. Observations of trans-equatorial propagation from Brisbane. Scientific Rept. 6, Contract AF 64(500)9, Queensland University, Australia (March 1962). AD-294 603; AFCRL 62-343.

Observations of trans-equatorial back-scatter propagation have been analyzed with particular reference to anomalous propagation. Seasonal, diurnal and directional variations are extracted and compared with the behavior of signals propagated via normal modes. Signal strength, fading and phase path measurements have been made at 16 mc/s and preliminary experiments carried out at 55 mc/s and over the range 15-30 mc/s using a back-scatter ionosonde.
DDC

THOMAS, J. A. Cross- and auto-correlation effects associated with anomalous transequatorial propagation at 16 Mc/s. Scientific Rept. 7 Queensland University, Australia (March 1962). Contract AF 64(500)9, AD-294 604; AFCRL 62-344.

Correlation analyses of certain aspects of anomalous transequatorial backscatter echoes have been carried out. These features are the starting time, duration and strength of the echo. No significant correlation exists between any of the above features and solar or magnetic disturbance effects. Echoes which commence early in the afternoon tend to be stronger and to last far longer than those which commence later. Days in which the echoes have similar duration or starting time or strength tend to be grouped together.
DDC

THOMAS, J. A. Transequatorial propagation analysis: Ionospheric height and frequency plots. Scientific Rept. 8, Contract AF 64(500)9, Queensland University, Australia (March 1962). AD-294 605; AFCRL 62-345.

A method of obtaining ionospheric data representative of regions where no ionosondes exist is described, and base height and critical frequency plots for the F sub 2 region are determined for a variety of great circle paths through Brisbane. The existence of ionospheric tilts capable of giving anomalous propagation of HF waves is demonstrated and several factors controlling the propagation conditions are discussed.
DDC

THOMAS, J. A. Lunar control of abnormal transequatorial propagation at 16 Mc/s. Scientific Rept. 9, Contract AF 64(500)9, Queensland University, Australia (March 1962). AD-294 606; AFCRL 62-346.

Lunar tidal analyses of the starting time, intensity and duration of anomalous transequatorial back-scatter echoes were carried out. Semi-diurnal lunar variations in starting time and duration are found, and an hypothesis is proposed to explain the observed phase of these variations.
DDC

THOMAS, J. A., and B. A. McInnes. Transequatorial propagation analysis: Ray tracing and mode analysis. Scientific Rept. 10, Contract AF 64(500)9, Queensland University, Australia (March 1962). AD-294 607.

Two methods of ray-tracing are used for the analysis of transequatorial propagation. A graphical method proved too inaccurate and was replaced by a computational method, suitably modified to take account of tilted ionospheric regions. It is found that paths involving low ray elevation angles are more likely to provide the long-range anomalous echoes detected, and the chief mechanism is that of reflection from ionospheric tilts particularly prevalent in equatorial regions during the early evening hours. Mixed-mode propagation of back-scattered signals must be fully considered in any attempt to account for the intensity of echoes received. Horizon-focussing effects must be considered in deriving the field strength of radio signals at great distances.
DDC

THOMAS, J. A., B. A. McInnes, and J. Crouchley. Exospheric propagation experiments. Scientific Rept. 11, Contract AF 64(500)9, Queensland University, Australia (March 1962). AD-294 608; AFCRL 62-348.

Experiments were carried out at 16 and 55 mc to search for possible exospheric propagation of back-scatter signals. A negative result was obtained over 6 weeks of continuous recording. The parameters of the system are examined and it is shown that if Gallet and Utlaut did, in fact, observe this type of propagation, then it should also have been observed at Brisbane.
DDC

THOMAS, J. A., E. W. Dearden, E. M. Matthew, R. W. E. McNicol, B. A. McInnes, D. G. Singleton, G. L. Goodwin, G. J. E. Lynch, and J. Crouchley. Final report on observations of field-aligned irregularities and transequatorial propagation. Scientific Rept. 16, Contract AF 64(500)9, Queensland University, Australia (March 1962). AFCRL-62-353.

This final report summarizes the work carried out at Brisbane in connection with investigations of field-aligned irregularities in the ionosphere and transequatorial propagation of radio waves. Information is given regarding the extent of such irregularity patches, their movements, and the correlations of the observed radar echoes from these irregularities with other ionospheric and geophysical phenomena. An association is proposed between large E-W elongated bands of the irregularities, Van Allen outer belt radiation counts, and an F-region anomaly already associated with the observation of red airglow arcs. The scintillation of radio transmissions passing through the irregularities of directions close to the field direction is probably the most sensitive means of detection of such irregularities. Anomalous transequatorial propagation of H.F. signals is associated with tilted reflection of very low angle radiation and occurs near the time of passage of the evening equatorial rise in F region heights. At midlatitude stations, an intervening normal 1F hop before the anomalous propagation hop may well exert a controlling influence on the use of this type of propagation. "Horizon focusing" effects must be considered in computations involving long distance H.F. propagation field strengths. In analyses of long-distance back-scatter data the importance of mixed-mode propagation should be stressed; i.e., the possibility of waves traveling outward by one path and returning to the receiver via a different path having a different time delay.
STAR

THOMAS, J. A. Lunar semi-diurnal tides in h'F and their influence on trans-equatorial radio propagation. Radio Science (NBS) 68D, 419-427 (April 1964).

The apparent partial dependence of anomalous transequatorial propagation on the phase of the moon has led to detailed investigation of the luni-solar tides in h'F for 19 stations having magnetic dip values between +51° and -57°.

An attempt has been made to determine whether the computed tides were significant by means of power spectrum analysis. Significant large amplitude semi-diurnal tides were found only for regions near the magnetic equator at local solar times between 1900 and 2300 hours.

A propagation analysis has further shown that appreciable mode pattern changes with the changing phase of the moon are not to be expected for 16 Mc/s transequatorial propagation from Brisbane.

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TITHERIDGE, J. E. The calculation of real and virtual heights of reflection in the ionosphere. J. Atmos. Terrest. Phys. 17, 96-109 (1959).

A rapid and accurate manual method is described by means of which the heights h corresponding to a given series of electron densities N can be calculated from an ionogram which shows the h'(f) curve for the ordinary or extraordinary wave. The method makes allowance for the presence of the earth's magnetic field. The virtual height is read only once at about twenty frequencies, and the calculation of a complete N(h) curve requires less than 15 min. A slightly modified method is described for use when very accurate results are required, as, for example, in a study of the fine structure of the E-layer.

The method makes use of a series of coefficients which may be quickly calculated once and for all, for a given place, with the aid of a desk calculating machine. The law assumed for the shape of the segments used in the analysis eliminates the necessity for the calculation and subsequent integration of the group refractive index in deriving these coefficients. The coefficients for the extraordinary wave are readily obtained by applying a correction to the "longitudinal" expression for the group refractive index.

It is shown how the same coefficients can be used in the inverse process of deriving an h'(f) curve from a known N(h) curve.

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TITHERIDGE, J. E. The use of the extraordinary ray in the analysis of ionospheric records. J. Atmos. Terrest. Phys. 17, 110-125 (1959).

When the ordinary ray trace on an h'(f) record is used to compute an electron density profile (N(h) curve) assumptions have to be made about (a) the form which the h'(f) curve would have taken at frequencies less than those actually employed, and (b) whether or not there is appreciable ionization in the "valley" between the E- and F-layers. In this paper it is shown how, by considering both the ordinary and extraordinary ray traces on the h'(f) record, it is possible to avoid both these assumptions to a considerable extent, and to deduce something about the electron distribution in the lower ionosphere and in any valley.

The method is applied to some experimental records, and it is shown (a) that neglect of the low-lying ionization leads to an overestimate of the height of the night-time F-region ionization of about 20 km where the plasma frequency is 2 Mc/s, and up to 15 km near the peak of the layer, and (b) that the "valley" between the E- and F-layers is small and nearly "full".
A

TITHERIDGE, J. E. Ionization below the night-time F-layer. J. Atmos. Terrest. Phys. 17, 126-133 (1959).

By making use of both the ordinary and extraordinary ray traces on h'(f) records it is possible to estimate the amount and distribution of low-lying ionization, having plasma frequencies less than the lowest frequency recorded. By applying this method to h'(f) curves obtained at night, it is possible to estimate the electron content of the E-region, even when its critical frequency is less than the lowest recorded frequency. Results are given for Slough and Watheroo for both summer and winter conditions, and for maximum and minimum sunspot numbers. Near midnight the amount of ionization below the F-region is equivalent to a constant density of about 4000 electrons/cm^3 extending down to a height of 130 km. The variation in the amount of this ionization near sunset gives a constant effective recombination coefficient of 2×10^{-8} cm^3/sec. F-layer heights calculated from the ordinary ray trace only are found to be too great by about 30 km at $f_N = 1$ Mc/s and 5 km at $f_N = 6$ Mc/s.
A

TITHERIDGE, J. The analysis of night-time h'(f) records. J. Atmos. Terrest. Phys. 20, 209-212 (1961).

The real heights of the ionospheric layers are normally determined by analysing the ordinary ray trace of sweep-frequency virtual height records.

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These $h'(f)$ records only extend down to some limiting frequency f_{min}, and it is usually assumed that the virtual height at lower frequencies is constant and equal to the value h'_{min} at f_{min}. This assumption causes the calculated real heights to be greater than the true values. The error is largest at night, when the calculated heights of the F-layer are commonly about 20 km too high at a plasma frequency (f_N) of 2 Mc/s, and 7 km high at 5 Mc/s (Titheridge, 1959a, b).

This error can be considerably reduced if the virtual height is assumed to be equal to h'_{min} from f_{min} down to a frequency just greater than 0.5 Mc/s (say 0.6 Mc/s) but is assumed to be equal to a value h_s for frequencies from 0 to 0.5 Mc/s so that the form of the complete ordinary ray $h'(f)$ curve to be analysed is as shown in Fig. 1. The height h_s is chosen in such a way that $h'_{min} - h_s$ is proportional to the amount of low-lying ionization and the analysis of the complete $h'(f)$ curve illustrated in Fig. 1 will provide an N(h) profile which is a good approximation to the profile which would have been deduced if the $h'(f)$ curve had been observed down to zero frequency. This paper describes how the starting height h_s may be determined.

The amount of this underlying ionization is approximately proportional to $h'_x - h'_{min}$, where h'_x is the observed virtual height of the extraordinary ray, of frequency f_x, which is reflected at the same true height as the ordinary ray of frequency f_{min} (Titheridge, 1959a, Section 2). Since the amount of underlying ionization in the calculated real height curve is proportional to the assumed value of $h'_{min} - h_s$, we require that $h'_{min} - h_s = K(h'_x - h'_{min})$. The value of K depends on the value of f_{min} and on the strength and direction of the magnetic field. It can be determined empirically, for any desired conditions, by calculating the value of h'_x resulting from a real height curve with known values of h'_{min} and h_s. Thus for conditions in S.E. England we get $h'_{min} - h_s = 4.6\ (h'_x - h'_{min})$ when f_{min} is 1.4 times the gyrofrequency f_H.

Some typical results are shown in Fig. 2. The dotted lines give the heights calculated by the normal methods in which h' is assumed to be constant and equal to h'_{min} at frequencies below f_{min}. The solid lines give the result of starting the calculations at 0.5 Mc/s with the starting height $h_s = h'_{min} - 4.6\ (h'_x - h'_{min})$. The calculated heights then agree exactly with the measured virtual heights of the ordinary ray, and also agree with the virtual height of the extraordinary ray at the frequency $f_x = 2f_H$. The broken line curves are taken from Titheridge (1959a) and were calculated to agree with the virtual heights of both the ordinary and extraordinary rays, at all frequencies, to within the experimental error of about 1 km. The solid line curves are seen to agree quite well with these more accurate results at frequencies above f_{min} (1.5 Mc/s).

This agreement is maintained at all seasons and sunspot numbers. 120 night-time $h'(f)$ records taken at Slough were analysed by each of the three methods used in Fig. 2. The normal analysis neglecting the effect of the underlying ionization differed from the results of the full analysis

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by a mean amount of 21 km at f_N 2 Mc/s. This was reduced to 3.7 km by beginning the analyses from a starting height h_s calculated as described above. In 230 Watheroo records which were analysed, a mean difference of 17 km was reduced to 4 km. The simple procedure suggested will thus reduce the errors, caused by the presence of ionization beneath the night-time F-layer, by about 5 times at frequencies above 1 Mc/s.

The difference between the solid and dotted curves in Fig. 2 gives the correction to the results of the normal ordinary ray analysis. The magnitude of the correction at any frequency is proportional to the value of $h'_x - h'_{min}$. The values given in Table 1 can therefore be used to determine the size of this correction under any required conditions, and for any value of the magnetic dip angle I.

The frequency f_0 at which the virtual height of the ordinary ray is measured need not be the same as the lowest observed frequency f_{min}. Calculations with other values of f_0 and f_x [such that $f_0^2 = f_x(f_x - f_H)$] show that, for a given value of $h'_x(f_x) - h'_0(f_0)$, the corrections are approximately proportional to $(f_x - f_H)^2$. For $f_0 = 1.4f_H$, the initial correction is equal to (5.48 - sin I) within 1 percent (Table 1). So it is found that the starting correction required at 0.5 Mc/s is given generally by

$$h'_{min} - h_s = 0.74\,(5.48 - \sin I)\,(f_x - f_H)^2[h'_x(f_x) - h'_0(f_0)].$$

If the real height calculations are started from 1 Mc/s (instead of 0.5 Mc/s) the starting correction required at this frequency is:

$$h'_{min} - h_s = 0.36\,(5.48 - \sin I)\,(f_x - f_H)^2[h'_x(f_x) - h'_0(f_0)].$$

These relations are accurate to within a few percent for all practical values of f_H, and for values of f_x less than 3 Mc/s. Larger values of f_x cannot be used in practice, since the values of $h'_x(f_x) - h'_0(f_0)$ become too small to measure accurately. In the routine analysis of ionospheric records the value of h'_x is measured at the lowest frequency f_x at which the extraordinary ray trace is visible. The corresponding value of h'_0 is then found by interpolating in the measured ordinary ray heights, and the initial real height h_s is calculated from the above relations.

When the extraordinary ray trace cannot be distinguished at frequencies below about 3 Mc/s, an estimated value of h_s should be used. This is obtained from other records taken at the same hour on different days. Its use gives reasonably accurate results since it is found that the values of h'_{min} are largest when the amount of underlying ionization is greatest, so that the values of h_s do not vary greatly from day to day.

Thanks are due to the Director of the Cambridge University Mathematical Laboratory for permission to use the electronic computer EDSAC II in these calculations.

Excerpt

TITHERIDGE, J. E. A new method for the analysis of ionospheric h'(f) records. J. Atmos. Terrest. Phys. 21, 1-12 (1961).

A method is given for calculating the real heights of reflection in the ionosphere, at a number of given frequencies, from the observed virtual heights at those frequencies. The complete real height curve is assumed to consist of a single smooth curve through the calculated points. This gives more accurate results than the lamination methods generally used, in which the real height curve is approximated to by a number of linear segments. So for routine calculations the present method requires less than half as many points as the lamination methods.
A

TITHERIDGE, J. E. The effect of collisions on the propagation of radio waves in the ionosphere. J. Atmos. Terrest. Phys. 22, 200-217 (1961).

Curves are given showing the effect of the electron collision frequency v on the group refractive index, for both the ordinary and extraordinary rays, under a wide variety of conditions. It is shown that collisions do not significantly affect the virtual height of radio waves reflected in the E- and F-layers of the ionosphere. It is also shown that the absorption of a radio wave reflected in the ionosphere can be obtained by integrating an absorption coefficient k_0, equal to v times the value of k/v at v = 0, up to the classical height of reflection. This simple procedure yields the same result as a full-wave calculation of the absorption.
A

TIURI, M. E., and J. D. Kraus. Ionospheric disturbances associated with Echo 1 as studied with 19-megacycle-per-second radar. J. Geophys. Res. 68, 5371-5385 (1963).

Description of observations at 19 Mc made between Nov. 1961 and Mar. 1962 which show a correlation between anomalous pulse-radar echoes and passes of Echo 1 (1960 Iota 1). The correlation is especially noteworthy between the starting times of the anomalous echoes and the passage of Echo 1 through the antenna beam, most echoes starting in the interval up to 20 min before the passage of the satellite. The effects of the time of day, the orbit range, the equator-crossing longitude, and the latitude of the satellite are also investigated. Some possible mechanisms are discussed.
IAA

TOMLINSON, J. M. A method of solving the integral equations for the vertical propagation of time-harmonic plane waves in anisotropic vertically inhomogeneous, non-magnetic media. Scientific Rept 100, Contract AF 19(604)-1304, Ionosphere Research Laboratory, Pennsylvania State University, University Park, Pa. (1 Feb. 1958).

A pair of coupled scalar integral equations are obtained for the horizontal components of the electric field of a time-harmonic plane wave which is propagating vertically in an anisotropic, vertically-inhomogeneous, non-magnetic stratum. A similar pair of coupled integral equations are obtained for the Forsterling-Rydbeck components of the same plane wave. For the practical cases (e.g., the ionospheric lower E layer F.-R. coupling and reflection regions) in which the stratum is bounded by strata where the F.-R. wave equations are practically uncoupled and W.K.B., the space derivatives are eliminated from the boundary condition terms in the integral equations. The integrals are approximated by Simpson's rule to obtain a system of algebraic equations for the values of the components at evenly-spaced points in the stratum. Matrix manipulation almost completely diagonalizes this system, leaving, at the most, only three nonzero sub-diagonals on each side of the main diagonal. For the case of negligible coupling (e.g., the lower E-layer F.-R. reflection region) the system of equations separates into two systems each having a matrix with one sub-diagonal of -1's on each side of the main diagonal, and zero's elsewhere. The final triangularization of this matrix is accomplished with a repetitive-loop digital computer program having only 30 instructions and using only 5 additional words of computer storage, regardless of the matrix size. Computer triangularization of the 5 x 5, 9 x 9, 17 x 17, and 33 x 33 matrices for an F.-R. reflection region problem which has an exactly-known wave solution yield reflection coefficients which converge to within 0.5% of the correct amplitude and 2° of the correct phase.
MGA

TOSHNIVAL, G. R., and B. D. Pant. Ionisation of Kennelly-Heaviside layer at Allahabad. Proc. Natl. Acad. Sci. India 5, 9-14 (1935).

Using the well-known pulse technique the ionisation of the E-region was found in the month of April. The morning and evening values, which are considered very reliable, show values for the critical frequency of 3.1 Mc./sec. and 4.6 Mc./sec, the latter being a maximum value observed at 7.22 p.m. on the 18th April. In an added note it is suggested that the use of higher power in the determination of the F_2 critical frequency would

enable a discrimination to be made between the high-temperature theory of Appleton and the absorption hypothesis of Kirby and others.
PA

TOSHNIVAL, G. R., B. D. Pant, R. R. Bajpai, and B. K. Verma. Study of ionosphere at Allahabad. Proc. Nat. Acad. Sci. India 6, 162-174 (1936).

Observations for November and December 1935, show that 75 meter waves are usually reflected from the F-region. Sporadic E reflections have, however, been observed on several nights. The noon ionization of the E region has been measured during the winter solistice period and found to be about 2 x 10^5 electrons per c.c. Both the group retardation as well as the stratification splitting has been observed, the former rather rarely. Long retardation echoes show the possibility of existence of ionized regions above the F-region. Complex echoes consisting of several peaks rapidly fading in and out have been seen several times. There seems to be no connection between the magnetic disturbances and the complex echoes. Observations for the reflection coefficient have been taken for the two rays, and values of reflection coefficient greater than unity have been observed. The results find a satisfactory explanation on the hypothesis of undulatory structure of the ionosphere together with the possibility of echo reception from direction other than vertical. Measurement of reflection coefficient late in the night shows that both the rays are absorbed in the reflecting region, a view contrary to those held by the English workers. The desirability of taking more observations in collaboration by several stations is pointed out.

TOSHNIVAL, G. R., Pant, B. D., and Bajpai, R. R., Radio studies of the upper atmosphere at Allahabad. Proc. Natl. Inst. Sci. India 3, 337-354 (1937).

The necessity of a thorough study of ionized regions of the upper atmosphere for a complete understanding of the problem of propagation of radio waves is now well recognized all over the world. Important investigations have been carried out in higher latitudes, and a considerable amount of data has been collected. The condition of the ionosphere is expected to be rather different in equatorial and tropical regions, andhence for the thorough understanding of the problem it is essential to collect data for these regions too. Realizing this, work has been started in India at Calcutta and at Allahabad. A considerable amount of data has now been collected at Allahabad, which is briefly presented here.
Excerpt

TOSHNIVAL, G. R., and B. D. Pant. Ionospheric height measurement in the United Provinces of Agra and Oudh (India). Nature 133, 947-948 (1944).

State measurements have been made at Allahabad. Describe few results.
M

TSCHU, K. K. On the practical determination of lunar and luni-solar daily variations in certain geophysical data. Austral. J. Sci. Res. 2, 1-24 (1949).

This is a continuation of two earlier papers, in which Chapman and Miller (9, cf. Miller 13) developed the mathematical theory of a convenient method for the determination of the lunar daily variations in geomagnetic and meteorological elements, and for estimating the probable error of any determination thus made. Important practical details of the work are given in the present paper, with examples of the calculations on suitable computing forms. It also includes a new application of the Chapman-Miller Method to the determination of a luni-solar periodic component first predicted and investigated in ionospheric data by Martyn (7).

UMLAUFT, G. Focusing of electromagnetic waves by E_s-clouds. J. Atmos. Terrest. Phys. 18, 253-255 (1960).

Histograms of I_0-values with and without influence of E_s obtained at Lindau and Tsumeb are shown. The observation does not lend itself to an explanation by means of focusing effects, the objection being that such abnormally high values are never observed in the absence of E_s echoes, which is the much commoner condition in this case. Two possible explanations of the phenomena are presented. First, it is shown that these observations can be explained by a focusing effect of the E_s clouds. Secondly, the phenomena is explained by assuming that E layer sometimes consists of clouds with dimensions of the order of kilometres.
MGA

URSI. Special report no. 2 on tidal phenomena in the ionosphere. General Secretariat of URSI, Brussels (approved for publication 1950).

In beginning this report for the International Union of Scientific Radio it is appropriate to state briefly why the subject is important both to science and to radio. It is increasingly clear that if we wish to understand the pecular behaviour of the principal ionospheric region, the F2 region, we must know how winds affect it. The regular rhythmic winds associated with air tides, especially the lunar tide, cause perturbations which can be detected in ionospheric data. The results of such studies are important in scientific problems such as terrestrial magnetic variations, and the world-wide oscillations of the atmosphere. The extension of these studies to the stronger winds probably associated with solar heating seems at the moment the best approach to better understanding and prediction of the complicated behaviour of the F2 region, a necessity for further improvement in short-wave radio communications.

Until about fifteen years ago it seemed adequate to regard the ionosphere as located in the tranquil cold region which was supposed to constitute the outer atmosphere. In still air, far above winds and storms, were formed the ionised regions important to radio communications. These regions were produced in the day-time by impact of solar ultra-violet radiation on air molecules or atoms, and they decayed during the hours of darkness. Each electron or ion so produced was supposed to spend its entire life-time near its birth place, its wandering curbed by collisions with neighbouring molecules.

This comparatively static picture gave an adequate account of the regions E and F1 at heights of about 100 and 200 km respectively: the theory of ionised region formation developed by Chapman was reconciled by Appleton with the observed daily variations of electron densities and height distribution. As data regarding the F2 region accumulated it became clear that for one region, and this the most important for radio communications, Chapman's theory was inadequate. The theory predicts maximum ionisation in mid-summer: the evidence is a general tendency for greatest F2 ionisation in mid-winter. In other ways too, in its daily variations and latitude distribution, the F2 region appears anomalous. It appears to have a symmetry about a terrestrial magnetic equator, a feature which finds no ready explanation.

Simple qualitative explanations of some of these F2 region anomalies were advanced by Hulburt and Appleton independently. They suggested that solar heating expanded the atmosphere at its uppermost levels, so reducing the density of ionisation in the F2 region. Unfortunately this attractive idea has not stood up to quantitative examination, although it has been a useful stimulus to subsequent investigation. About this time Martyn and Pulley put forward evidence that the F2 region was very hot, temperatures of the order 1000° C being found at all times. This suggests that the temperature of the upper ionosphere is controlled by solar radiation directly, the prevailing temperature being that at which the heating due to absorption of solar ultra-violet rays is balanced by the cooling due to infra-red radiation from air molecules. (This condition is quite different from that in the cold stratosphere, where the temperature appears to be mainly controlled by infra-red radiation from the earth). So we may expect that in the F2 region there will be quite appreciable heating and cooling in the course of the day, as the sun rises and sets. This world-wide heating and cooling must give rise to wind systems. A little consideration of the geometry of such air circulations shows that the horizontal air velocities must be much larger than the vertical ones. In fact, the ratio u/w of these velocities must be comparable with a/h where a is the radius of the earth and h the thickness of the heated atmospheric region. This would give horizontal winds about 100 times stronger than the vertical ones in the F2 region.

At first sight this conclusion might appear to have little bearing on the anomalous vertical expansions of the F2 region. There is however a factor governing the motions of electrons (and ions) which becomes of vital importance at the low pressures existing in the F2 region. It is the earth's magnetic field. At pressures of about 10^{-5} mm of mercury, elementary charged particles are constrained to orbits which are spirals around the lines of the earth's field. An applied force, such as is provided by the repeated impact of the uncharged air molecules in a wind, has negligible effect in moving electrons across the lines of magnetic force, but can push them freely along those lines. Since in most parts

of the world the magnetic field is inclined, it follows that a strong horizontal wind can produce much vertical movement of electrons (and associated ions). So we reach the remarkable conclusion that a small uneven heating of the atmosphere, producing small vertical atmospheric expansions, can yet produce large vertical movements of an ionised layer at the height of the F2 region. Moreover if, as is likely, these horizontal winds vary with height, then the vertical movements of the F2 region will be accompanied by changes of electron density (*).

Up to this point we have considered heating and cooling as occurring only in the F2 region itself. While it is possible that a circulation of the kind described might be confined to these upper levels, there is a strong tendency for the atmosphere to oscillate as a whole. In fact there is strong reason to believe that an even more important cause of world-wide oscillations is the comparatively small daily change of air temperature at the earth's surface. Although the temperature changes are small, the energy changes are large because of the comparative deneseness of the air at these low levels. It is certain that the energy here involved is adequate to cause the world-wide oscillations in the lower atmosphere. There is no need to invoke an ionospheric tail to wag the tropospheric dog. We shall see later that in general the whole atmosphere tends to act like a waveguide or cavity resonator for world-wide oscillations; there is a tendency for the horizontal energy flow to be the same at all heights. This means that u^2 x air density tends to be independent of height, so that u tends (**) to increase exponentially with height. So the observed movements at F2 levels might even be adequately accounted for as a manifestation of the world-wide oscillation arising from the small low-level temperature variations. It is not yet possible to assess how much of the F2 wind systems is due to this latter cause, and how much is of local origin.

When we start to search directly for evidence of solar tidal movements in ionospheric data, a difficulty appears immediately. We seek oscillations whose periods (24, 12, 8 hours, etc.) coincide exactly with those already necessarily present in the data from the simplest considerations of electron production. The electron density and the height of the maximum density

(*) It will be seen later that this account of F2 region disturbances is somewhat over-simplified.

(**) This general trend may be departed from locally in the vicinity of nodes, as explained later in this section. Also in some modes, barriers to the vertical flow of energy exist at certain levels: however, such barriers are only partially effective, their thickness being small compared with the wavelength of the oscillation.

of a simple ionised region are closely related to the sun's elevation at the time of observation. Hence there must, from this cause alone, be strong periodicities in the data, of 24, 12, 8 hours, etc. It is impossible in these circumstances to disentangle the "tidal" components from the "ion production" components, without more detailed knowledge of the processes involved in at least one of these.

A way out of this serious impasse is provided by the tidal action of the moon on the earth's atmosphere. But before discussing this a brief digression on the meaning of the word "tide" is desirable. Commonly it is applied to the oscillatory motion of the oceans produced by the gravitational pulls of the moon and sun. The motion of the water is mainly horizontal, and is substantially the same at the surface as at the ocean bottom. By a natural process of analogy the word has been similarly applied to those rhythmic movements of the earth's atmosphere which reveal themselves in the well known solar and lunar oscillations of the barometer. It has been shown by Chapman however that in the production of the solar barometric oscillation thermal forces are comparable with the gravitational. In spite of this, it is still customary to call this oscillation a "tide". A further complication arises because air, unlike water, is easily compressible. It is unnecessary for air to pile up vertically, as does a converging flow of water: air may be compressed instead. This results in more complex flow patterns, and so it is possible for tidal flow in the atmosphere to have different velocities, and even opposite directions, at different heights. We may even have "high tide" recorded by a barometer at the ground while a barometer in the upper could simultaneously register "low". (The barometer simply weighs the air above it). In spite of these complications and differences from simpler oceanic tides, it is still customary to apply the word "tide" to rhythmic oscillations of the atmosphere, however produced, and whatever their form, so long as they are world-wide in character and have periods which are identical with, or harmonics of, the solar or lunar day. To this practice we shall adhere.

So far as we know, the moon affects our atmosphere dynamically only by its gravitational pull, so the lunar forces at work on the air are known with precision. If we knew better the vertical temperature distribution, particularly above the 80 km level, it would even be possible to calculate the air motions in the ionosphere with some accuracy. But the great advantage of studying lunar tidal variations in the ionosphere lies in their (mean) periods, which are 24 h 51 m and its simple sub-multiples, especially the strong semi-diurnal variation of period 12 h 25.5 m. These are sufficiently different from the corresponding solar periods to permit the isolation of purely lunar tidal variations from ionospheric data recorded at hourly intervals for several years. Such data exist for many

parts of the world, and as they accumulate, more and more precise determinations of the lunar variations become possible. Interpretation of these helps us to understand how relatively feeble winds affect the ionosphere. This in turn should help us to isolate the effects of the stronger winds due to the sun, and so to achieve a fuller understanding of the vagaries of the F2 region.
Excerpt

UTLAUT, W. F. Ionospheric effects due to nuclear explosions. NBS Rept. 6050, National Bureau of Standards, Boulder, Colo. (30 April 1959).

Vertical-incidence ionograms of every 15 min routine observations with a type C-2 ionosonde at the U. S. Nat. Bur. of Standard's Field Station at Maui, Hawaii located approximately 1450 km NE of Johnston's Island are presented. The discussion deals with the extreme disturbances on Aug. 1 and again Aug. 12 coinciding with the high altitude nuclear explosions over Johnston Island. Complete radio fadeouts at several South Pacific circuits, abnormal magnetic perturbations, and a rare tropical aurora (observed at Apia) are reported to be effects of the blasts.
N

VAN SABBEN, D. Ionospheric current systems caused by non-periodic winds. J. Atmos. Terrest. Phys. 24, 959-974 (1962).

Investigation of the possibility that zonal and meridional winds, independent of longitude, will produce ionospheric current systems. To treat the problem mathematically, a model ionosphere is used, divided into an equatorial region with horizontal magnetic field and northerly and southerly regions with vertical magnetic field. The ionization is schematically assumed to be zero at the night side and constant at the sunlit side of Earth. It appears that certain zonal or meridional wind distributions, if existent, would be almost as effective as the periodic wind systems in producing a current vortex. Observed ionospheric winds of nonperiodic character are strong enough to warrant the conclusion that they will affect the current system of the daily variation appreciably.
IAA

VAN ZANDT, T. E., R. B. Norton, and G. H. Stonehocker. Photochemical rates in the equatorial F2 region from the 1958 eclipse. J. Geophys. Res. 65, 2003-2009 (1960).

The F_2-region electron-density data from the eclipse on October 12, 1958, at Danger Islands has been analyzed with a new method. It is shown that (1) temperature changes and transport of electrons were probably negligible during the eclipse, and (2) the rate of photoionization q(h) and the linear recombination coefficient ('attachment coefficient') β(h) can be approximated between 290 km and 400 km by

$$q(h) = 880 \exp\left[-(h-300)/136\right] \text{ electrons cm}^{-3} \text{ sec}^{-1}$$

$$(h) = 6.8 \times 10^{-4} \exp\left[-(h-300)/103\right] \text{ sec}^{-1}$$

where the height h is measured in kilometers. The rate of formation of ion pairs between 290 and 400 km is $(.76)10^{10}$ ion pairs/cm^2 sec, or about (0.25) ergs/cm^2 sec. This implies a total rate of energy absorption in the F region of at least 2 ergs/cm^2 sec.
A

VELDKAMP, J., and J. G. Scholte. Some remarks on the equatorial electrojet, as revealed by the analysis of solar flare effects. Indian J. Met. Geophys. 5, 203-212 (Dec. 1954).

Maps are reproduced of the current vectors of three strong solar flare effects, viz. 1953 Oct. 14d 09h 50m, 1953 Oct. 14d 14h 23m and 1950 Feb. 13d 19h 23m. The well-known electrojet over South America is revealed by large currents at the stations Hu and Va. No such large currents are observed at Bi and MB in equatorial Africa. Baker and Martyn have extended the atmospheric dynamo theory of the diurnal variation by taking the Hall effect into account, and have succeeded in explaining the equatorial anomaly. As these authors assumed a coincidence of the geomagnetic and geographic equators, this theory is unable to provide an explanation of the different values of the anomaly at different points of the equatorial belt. In this paper the current system is calculated for an oblique dipole axis. Large anomalies are found at those points where the equators reach their greatest deviation, whereas in Equatorial Africa the calculated S_q variation is very small; in the Pacific the anomaly must be very pronounced too. More data are needed to check this result.
MGA

VELDKAMP, J., and D. Van Sabben. On the current system of solar-flare effects. J. Atmos. Terrest. Phys. 18, 192-202 (1960).

The electric current system responsible for the great solar flare effect (s.f.e.) of 23 March 1958, is compared with the currents of the normal daily variation of the geomagnetic field. Whereas the standard S_q-currents are symmetric with respect to the geographic equator, the pattern of the currents of the s.f.e. as well as that of the currents of the normal daily variation at the time of the s.f.e. are controlled by the magnetic equator. The same result is found by a re-examination of selected s.f.e.s published in the IATME Bulletins nos. 12f and 12h. It is shown that the s.f.e. currents must flow in a region where the disappearance of electrons follows an attachment law. The decrease of the s.f.e. leads to a loss coefficient $\beta = 5 \times 10^{-4}$ sec^{-1}, which compares with the known value for the D-layer.

VENKATESWARLU, P., and R. Satyanarayana. Some studies on sporadic E. J. Sci. Indus. Res. 20B, 8-10 (1961).

Results of studies of sporadic E ionization made during period Sept. 1959 to Jan. 1960 at Tirupati, India, have been presented; monthly mean maximum fE_s has been found to occur around noon; abnormally high values of fE_s observed on certain occasions have been explained as due to thunderstorm activity.
EI

VERMA, J. K. D., and R. Roy. Polarization of the echoes from the ionosphere. Indian J. Phys. 30, 36-46 (1956).

Some experimental studies on the polarization characteristics of the echoes from the ionospheric layers have been presented. The details of an improved type of radio polarimeter which can work in conjunction with a high resolution radio sonde equipment have been described. The high resolving limit of the equipment made it possible to record the true polarization patterns of the echoes due to normal reflection and those due to irregularities in the ionized regions. A method has been indicated for the identification of the thin layer type of E_s echoes from other types on the basis of their polarization characteristics.
A

VESTINE, E. H., L. Laporte, I. Lange, C. Cooper, and W. C. Hendrix. Description of the earth's main magnetic field and its secular change, 1905-1945. Publication 578, Carnegie Institution of Washington (1947).

The present publication is a summary, mainly in the form of maps, of the results of land and ocean magnetic observations made since 1905. It is a continuation of the series of volumes of "Researches of the Department of Terrestrial Magnetism" only in the sense that the greater part of the observational material was obtained by the Department.

The world-wide distribution of magnetic observatories, land-survey stations (including repeat stations where magnetic observations have been made more than once), and ocean stations is indicated on charts. Tables are presented and their use for the removal of the influences of various

geomagnetic fluctuations upon the values measured at the different stations is described. The procedure for deriving from measured elements (usually D, H, and I) the elements X, Y, Z, and F is discussed. For about 2,000 repeat stations and 100 observatories, graphs have been drawn of the measured and derived elements, corrected for geomagnetic fluctuations, as a function of time since 1905; about 100 graphs for each of seven elements are reproduced in this volume.

With the graphs as a basis, isoporic charts were prepared through the following operations. Values of the slopes of the graphs were scaled at the four epochs, 1912.5, 1922.5, 1932.5, and 1942.5, to give secular-change estimates. These results were plotted on large-scale maps of the world, and isoporic charts were prepared for H and D (and simultaneously for X and Y) which were adjusted to mutual consistency so that the vertical component of curl of the field and the line-integrals of the north and east components of intensity of secular change vanished to a good degree of approximation. Spherical harmonic analyses of the X- and Y-components of secular change were made with fair success by means of automatic machines. The values of the vertical components of secular change at each epoch were computed; the syntheses of values using coefficients found for the Z-component, on the assumption that no part of the secular-change field is of external origin, proved helpful in preparing the world isoporic charts of vertical intensity, especially in the polar regions. They also ensured good consistency between the charts for vertical intensity of secular change and those for the horizontal component. Corresponding isoporic charts in I and F were also constructed.

The adjustments for consistency were largest over ocean areas and in the polar regions; over land areas there resulted only slightly different general line-configurations, which tended to improve the agreement between the charts and the actual observations. The positions of the more outstanding singularities in the field of secular change were also derived and indicated. The isoporic charts for all epochs are reproduced in this volume.

The isoporic values obtained were next used to reduce all available magnetic observations made in any year since 1905 to the epoch 1945.0 through adding to the measured values, usually corrected for geomagnetic fluctuations, the increments in fields indicated for each 10-year epoch required. The results in D, H, and Z for 1945.0 were entered upon large-scale sectional maps consisting of 15 partial Mercator projections, a north polar projection, and a south polar projection. The charts for H and D were tested for mutual consistency in a manner similar to that employed for the corresponding isoporic charts. A spherical harmonic synthesis was used to check the line-configurations of charts for the vertical component of the field with fairly good results, assuming the Earth's field to be entirely of internal origin.

Main-field charts in three sections each were also constructed in X, Y, I, and F for 1945.0, and, with the charts for D, H, and Z, are included here.

In preparation for a later volume in this series, the results of the spherical harmonic analysis have been employed to compute isomagnetic charts of the main field and isoporic charts for epoch 1945.0 for various heights within and beyond the Earth's atmosphere.

A

VESTINE, E. H., L. Laporte, I. Lange and W. E. Scott. The geomagnetic field, its description and analysis. Publication 580, Carnegie Institution of Washington, Washington, D. C. (1947).

This book continues a descriptive study of geomagnetism begun with Carnegie Institution of Washington Publication 578, which was principally concerned with the description of the Earth's main magnetic field and its secular change. The present volume extends this work to the various known geomagnetic variations, with inclusion of some analyses.

To a considerable extent, the present book is actually a by-product of Publication 578, since extensive information on geomagnetic variations was required for the improving of estimates therein of geomagnetic secular change for the period 1905 to 1945. Because the latter required descriptive information respecting shorter-period time-variations on a world-wide scale and over these many years, the general scope of coverage is considerable. Moreover, the emphasis has been upon the description rather than upon the interpretation of results.

It is believed that the two volumes together comprise the first convenient detailed compendium of geomagnetic data especially suited to the needs of those engineering workers who are mainly concerned with the practical applications of geomagnetism. The wide use of illustrative diagrams (many initially drawn as a training exercise for the draftsmen who drew the maps of the first volume) enhances the effective description of geomagnetic phenomena of our environment. The books emerge therefore as a kind of picture supplement to the standard treatise Geomagnetism; the writer hopes that his teacher, Professor Chapman, senior author of that treatise, will not object to such suggestion, provided he be not held at fault for any mistakes that we may have made.

In the course of pursuing the major descriptive objectives of this war project, the writers could not resist the temptation to undertake some serious investigations of the extensive new data available. Hence attempts at explanation of certain phenomena will be found at intervals, between the stacks of figures and tables, along with some short discussions linking the present with previous work. The writers hope that in this way a more interesting and readable account has been provided.

This volume completes a final report on work done for the most part during the war period 1942 to 1946 under Contract NOrd-392.

Excerpt

VESTINE, E. H. Note on direction of high auroral arcs. J. Geophys. Res. 65, 3169-3178 (1960).

Relationship between geomagnetic micropulsations and pulsations in auroral luminosity; certain homogeneous auroral arcs noted by Stormer at height of 200 km in central Norway have mirror point for trapped particles computed to be below ground level in south Indian Ocean; magnetic field gradients near night-time electrojets near northern and southern auroral zones will change sign of drift of auroral particles. EI

VESTINE, E. H. The upper atmosphere and geomagnetism. IN: Physics of the Upper Atmosphere, 471-511 (Academic Press, 1960).

Excerpt

VILLARD, O. G., Jr., S. Stein, and K. C. Yeh. New evidence of anomalous transequatorial ionospheric propagation. IRE (1957) Natl. Convention Record Part 1, 19-30.

Echoes of exceptionally long delay detected by a H. F. radar located in the West Indies are interpreted as ground backscatter propagated by two successive reflections from the F-region of the ionosphere, without intermediate ground reflection. Propagation of this sort between two points on the earth requires an initial ionospheric tilt followed by one of opposite sign. Tilts of the required sort take place regularly in equatorial regions as a consequence of two daily bulges in the ionosphere, one occurring at approximately 1900 local time over the geomagnetic equator, and the other occurring around noon in the vicinity of the sub-solar point. It is shown that tilt-supported propagation can take place at frequencies considerably in excess of the MUF predicted in the usual way. It is believed that these results may explain the reports by radio amateurs of anomalous propagation between North and South America.
A

VILLARD, O. G., Jr. S. Stein, and K. C. Yeh. Studies of transequatorial ionospheric propagation by scatter-sounding method. J. Geophys. Res. 62, 399-412 (Sept. 1957).

Echoes of exceptionally long delay detected by a HF radar located in the West Indies are interpreted as ground backscatter propagated by two or more successive reflections from the F-region of the ionosphere, without intermediate ground reflection. Propagation of this sort is associated with tilts in the reflecting layers. Pronounced tilts are encountered regularly in equatorial regions; one occurs almost daily at approximately 1900 local time over the geomagnetic equator; another occurs around noon in the vicinity of the subsolar point. It is shown that tilt-supported propagation can take place at frequencies considerably in excess of the MUF predicted in the usual way. It is believed that these results may explain the reports by radio amateurs of anomalous propagation between North and South America.

For comments on the above paper, see R. Silkerstein. J. Geophys. Res. 62, 645-646 (Dec. 1957).
MGA

VINCENT, W. R. and F. H. Smith. A summary of literature pertaining to radio studies of meteors and meteor trails. SRI, Stanford Research Institute, Menlo Park, Calif. Project 1422, Contract AF 19(604)-1517 (January 1960).

A comprehensive survey of the literature pertinent to radio studies of meteors is presented. An abstract is given of each article, paper, report, or book that was available in English. A separate list without abstracts is given of material published in the Soviet Union and in Eastern European countries.
A

VINCENT, W. R. Research engineering and support for tropical communications. Semi-annual Rept. 1, Project 4240, Contract AF 19(604)-1517, Stanford Research Institute, Menlo Park, Calif. (March 1963).

The purpose of the project is to support the Combat and Development Test Center, a joint Thailand-United States agency, in the areas of tactical and tropical communications. The United States Army Electronics Research and Development Laboratory and Stanford Research Institute have created in Bangkok a Communications Research Laboratory, to be staffed by both Thai and United States personnel. This laboratory is presently, housed in a van complex. A C-2 vertical sounder, supplied by the United States Army Radio Propagation Agency, is being used for the study of the equatorial atmosphere. A remote area has been established for testing man-pack radio sets in a tropical environment. Word lists in the Thai language are being prepared, with cooperation from the United States Army Language School at Monterey, for use in this testing.
A

VINCENT, W. R. Voice tests on man-pack radios in a tropical environment. Res. Memo 2, Project 4240, Contract AF 19(604)-1517; Stanford Research Institute, Menlo Park, Calif. (July 1963).

Under the direction of the Advanced Research Projects Agency and the United States Army Electronic Research and Development Laboratory, Stanford Research Institute conducted a field test program to compare the performance of selected man-pack radio sets under various tropical terrain and weather conditions. Initial steps had already been taken to establish a Tropical Communication Laboratory as part of the Combat Development and Test Center (CDTC) in Thailand. The formation of the

basic laboratory and the assignment of personnel were hastened to accomplish the desired field tests.

This report describes the results of voice tests on the selected man-pack radio sets in a tropical forest environment. It will be followed by reports on the performance of the sets in other terrain environments.
Excerpt

VINCENT, W. R. Field tests on man-pack radios in a tropical environment. Res. Memo 3 on Project 4240, Contract AF 19(604)-1517, Stanford Research Institute, Menlo Park, Calif. (July 1963).

Under the direction of the Advanced Research Projects Agency and the United States Army Electronic Research and Development Laboratory, Stanford Research Institute conducted a field test program to compare the performance of selected man-pack radio sets under various tropical terrain, vegetation, and weather conditions. Research Memorandum 2 under this contract describes results obtained in a tropical forest area. This memorandum contains data on all tests completed to its date of issue, including those data presented in Research Memorandum 2, so that all test data can be available in one report and comparisons can be made.

Initial steps had been taken to establish a Communication Laboratory as a portion of the Combat Development and Test Center (CDTC) in Thailand. The formation of the basic laboratory was hastened and personnel assignments altered to provide adequate field test crews. Laboratory equipment did not become available to support the field effort until the later stages of the test program. However, the availability of a central headquarters, a temporary laboratory, and the meager repair facilities and support did facilitate the field tests somewhat.

This report describes the results of voice and CW tests on selected man-pack sets. Tests were conducted in the tropical forest area in southern Thailand, the rice paddy area of the low delta region near Bangkok, and the mountains about 100 miles north of Bangkok. Figure 1 shows the location of the test areas. More detailed maps of the test areas are shown in Sec. II.
Excerpt

VOGLER, L. E., and J. L. Noble. Curves of ground proximity loss for dipole antennas. NBS Tech. Note 175, National Bureau of Standards, Boulder, Colo. (20 May 1963).

Ground proximity loss, defined as the decibel ratio of antenna input resistance to its free space resistance, is presented in graphical form

for four types of antennas: vertical and horizontal electric and magnetic elementary dipoles. Assuming a non-layered ground characterized throughout by a relative dielectric constance ϵ_r and conductivity σ, curves are given showing the ground proximity loss for a wide range of values of ground constants, antenna height above the ground surface, and frequency.

WASHBURN, C.L., R.P. Olin, F.H. Johnson, and W. Woronka. Transequatorial F-layer propagation study. Final Report, Contract AF 30(602)-2506, ITT Federal Laboratories, Nutley, N.J. (14 June 1963). RADC-TDR-63-178.

This report discusses transequatorial F-layer propagation (TEF) in the 30 mc to 100 mc frequency range performed under contract AF 30(602)-2506.

Data was obtained on the characteristics of one-way transmission in the Western Hemisphere during July to October 1962. Six fixed-frequency transmitters in Balboa, Canal Zone, transmitted simultaneous CW signals on a 24-hour-per-day schedule, while the received signal outputs from six receivers located 4800 km away in Santiago, Chile, were continuously recorded.

At the inception, it was considered that TEF propagation would be critically limited because of the present sunspot cycle minimum. This study demonstrates TEF signals are observed regularly between 30 and 50 mc and sometimes as high as 75 mc. Signal strengths were high and at times were close to the calculated free space signal strength, strongly suggesting ray focusing. Rapid fading of the signal was observed. The depth of fading varied from at least 35db, to shallow fading of a few db. During periods of higher sunspot activity, the transmission of frequencies in excess of 100 mc can be expected. Results are fully substantiated in this report by many actual signal records, analyzed signal data, and a comprehensive discussion of supporting geophysical theory.

Sound engineering recommendations are presented for the continuation and expansion of this important work. These recommendations take on particular significance in view of the new and revealing evidence now available on TEF modes. The potential use and immediate application of TEF modes are becoming increasingly clear in the communications and detection fields.

A

WATTS, J.M., and K. Davies. Rapid frequency analysis of fading radio signals. J. Geophys. Res. 65, 2295-2301 (1960).

The purpose of this paper is to illustrate the results obtained from a system of inexpensive spectrum analysis of long time series, extending months and even years. The stored data are capable of being analyzed conveniently and rapidly at the end of the period or at intervals. Examples of geophysical phenomena capable of being analyzed by this technique are extra-low-frequency radio noise, geomagnetic variations, and the phase and amplitude of ionospherically and tropospherically propagated radio signals.
Excerpt

WEISS, A. A. Solar tides in the F_2 region from the study of night-time critical frequencies. J. Atmos. Terrest. Phys. 4, 175-183 (1953).

Night-time critical frequency variations at 25 ionospheric stations are analysed by season and by latitude for semi-diurnal solar tidal terms. The amplitude and phase of the vertical drift velocity of electrons so found are consistent with accepted tidal theory, and an estimate of the height-gradient of the vertical drift is obtained. Two parallel analyses are made, on the alternative assumptions that decay proceeds according to a recombination law or to an attachment law. The low values found for the decay coefficients preclude any decision as to which of these two decay processes is actually operative.

WELLS, H.W. Critical-frequency observations of the E-layer at the Huancayo magnetic observatory. Terrest. Mag. Atmos. Elec. 39, 209-214 (1934).

This paper describes the nature and characteristics of the reflections from the E-layer of the ionosphere as observed at the Huancayo Magnetic Observatory, and gives a comparison of the results obtained with similar investigations in the higher latitudes. It is shown that no marked critical frequencies are in evidence, and that the transition from the E-region to an upper ionised layer, or vice-versa, is a gradual process with little evidence of the long retardations which are frequently observed in the

higher latitudes. There is, however, a definite and smooth diurnal variation of estimated maximum ionisation which peaks around noon. The results indicate that the refractive index of the electromagnetic waves returned from the region of the maximum ionisation of the E-layer is complex and that dissipation is appreciable. Epstein's conclusion, that if the collisional frequency is large, part of the energy will be reflected and part transmitted, is borne out by these observations. It may be noted that this appears to be the necessary condition for the qualitative fulfillment of the so-called "atmospheric-dynamo" theory of diurnal variation of the earth's magnetic field.
A

WELLS, H.W., and L.V. Berkner. Polarisation of radio waves from the ionosphere near the geomagnetic equator. Terrest. Mag. Atmos. Elec. 41, 75-82 (1936).

Theory predicts that in the special case of propagation of a wave in the ionosphere with its wave-normal perpendicular to the earth's magnetic field at all points of the wave-path the two wave-components returned should be plane polarised in mutually perpendicular planes. Polarisation experiments have been conducted from the Huancayo Magnetic Observatory (Peru) 2° 10' from the geomagnetic equator in order to check this theory. The two components are found as predicted with the electric vector of the ordinary wave-component plane polarised in the magnetic north-south plane and the extraordinary component in the magnetic east-west plane. The reduction of the refractive index of the medium for any given number of charges is found to be greater for the extraordinary wave-component.
PA

WELLS, H.W., and H.E. Stanton. The ionosphere at Huancayo, Peru, Nov. - Dec. 1937. Terrest. Mag. Atmos. Elec. 43, 169-171 (1938).

On November 17, 1937, at the Huancayo Magnetic Observatory, in Peru, of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, continuous operation of recently-developed ionospheric apparatus was started. (Identical equipment was installed at the Watheroo Magnetic Observatory in Western Australia during April and May 1938.) The new apparatus covers frequencies from 16.0 mc/sec to 0.516 mc/sec every 15 minutes, automatically registering the virtual heights of the ionospheric regions. It is a powerful tool for radio exploration of the Earth's outer atmosphere, and its continuous operation is likely to give an excellent picture of the ionosphere.

WELLS, H.W. and H.E. Stanton. Ionospheric characteristics at Huancayo, Peru, Dec. 1937, through Dec. 1938. Terrest. Mag. Atmos. Elec. 44, 326-334 (1939).

The first automatic multifrequency ionospheric equipment developed by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, was installed at the Huancayo Magnetic Observatory in the latter part of 1937. Continuous recordings over a limited range were started in November and operations over the entire frequency-range, namely, 16.0 to 0.516 mc/sec, were initiated in December 1937. Since then the apparatus has operated continuously for 24 hours each day except for occasional short intervals necessary for maintenance to the equipment. The data, therefore, are entirely homogeneous.

WELLS, H.W. Multi-frequency recordings of radio wave polarization near the geomagnetic equator. Terrest. Mag. Atmos. Elec. 45, 353-358 (1940).

Theory of radio wave propagation predicts that in the special case of propagation of a wave in the ionosphere with its wave normal perpendicular to the earth's magnetic field at all points along the wave path, the two wave components returned should be plane polarized in mutually perpendicular planes. The Huancayo Magnetic Observatory (Peru) of the Dept. of Terrestrial Magnetism of the Carnegie Institution of Washington is suitably located for special polarization tests under the conditions above outlined, since the inclination of the earth's magnetic field is only some 2° 14' from the horizontal. Earlier tests at this location in 1935 confirmed the general theory for propagation in the F, F_1 or F_2 regions. It was shown that a simple doublet aerial oriented in magnetic N-S plane would record only the ordinary wave component; while an aerial in the magnetic E-W plane would record only the extraordinary wave component. Recent tests made with automatic multi-frequency apparatus are found to be in complete agreement with earlier results, and evidence is presented which warrants extension of earlier conclusions to include E-region propagation under certain conditions.
PA

WELLS, H.W., and R.C. Coile. The ionosphere at Huancayo, Peru, July to Sept. 1940. Terrest. Mag. Atmos. Elec. 46, 83-86 (1941).

No abstract available.
PA

WELLS, H.W. Ionospheric investigations at Huancayo magnetic observatory (Peru) with applications to wave transmission theory; abstract. IN: IRE Convention outlines radio's expanding role. Electronics 15, 33-34 (Feb. 1942).

H.W. Wells of the Carnegie Institution of Washington delivered a paper entitled "Ionospheric Investigations at Huancayo Magnetic Observatory (Peru) with Applications to Wave Transmission Theory". The first portion of this very interesting paper was concerned with the behavior of radio signals in the ionosphere. Low frequency waves and medium waves are reflected by the ionized layer commonly known as the ionosphere and high frequency signals pass through it out into space. The speaker explained how the characteristics of the ionosphere varied from day to night and from one part of the year to the next. A curious phase of the behavior of the ionosphere is that when it changes in the northern hemisphere at the beginning of the northern winter, it would ordinarily be expected to make the converse change in the southern hemisphere, but it doesn't. The same changes seem to take place at the same time throughout the world. The observations made at the Huancayo observatory are correlated with two other observatories operated by the Carnegie Institution in Alaska and in Australia. Mr. Wells described briefly the multi-frequency apparatus in use at Huancayo for the determinations of ionosphere characteristics at that location.

The effect of sunspot activity on the characteristics of the ionosphere and consequently on radio communication was also discussed. Slides of photographs of the sun showing the travel and growth of sunspots were shown together with ionosphere characteristics. It was indicated that at certain phases of sunspot life, the ionized layer disappeared from our atmosphere and with it radio communication. The aurora borealis which was visible over a large portion of the earth on the evening of September 18, 1941 and caused widespread disruption in radio communication occurred two days after sunspots were on that part of the sun's surface which was "aimed at the earth" as Mr. Wells put it. It was said that two days traveling time was necessary for the corpuscles of energy associated with the sunspots to reach the earth and have an effect.
EEMI

WELLS, H.W. Earth's magnetic field and actual heights in ionosphere. J. Geophys. Res. 47, 75-79 (1942).

By measuring magnetoionic separation at critical frequency, computes diurnal variation of height of maximum electron density at Huancayo. Daytime heights exceeded nighttime values. Range was 200 - 500 km.
M

WELLS, H.W., and A.H. Shapley. Eclipse-effects in F_2-layer of the ionosphere. J. Geophys. Res. 51, 401-409 (1946).

Observed eclipse at College, Alaska; Huancayo, Peru; and Watheroo, Australia. Puzzled by recession in ion density slightly prior to eclipse. Attribute it to eclipse of limb of sun. Observed an unusual layer formation during eclipse at Huancayo. The old F_2-layer rose, and a new, more highly ionized layer appeared below it at 350 km. Estimated F_2-layer recombination coefficient as $1 \rightarrow 5 \times 10^{-10}$.
M

WELLS, H.W. Sporadic E-region ionization at Watheroo Magnetic Observatory 1938-1944. Proc. IRE 34, 950-955 (1946).

Characteristics of sporadic E (Es) at the Watheroo Magnetic Observatory, Western Australia, have been determined from continuous ionospheric recordings since June, 1938. Average diurnal curves show most frequent occurrence at night with maximum near midnight, local time, although there is a tendency for the most intense Es to occur during day hours. The seasonal features of Es already well established for the Northern Hemisphere have been confirmed for the Southern Hemisphere with a maximum of Es in local summer months. Annual trends show increasing values from 1938 to 1941 with decreasing values from 1941 through 1944. An upward trend is indicated for 1945, suggesting a minimum in 1944. This annual characteristic is significant in view of an apparent inverse relationship with sunspots in the Northern Hemisphere. Separate analyses were made of Es to determine 40- to 80-megacycle propagation conditions for a 1000-mile path in percent of time for selected hours of November, 1941, which was the period of greatest Es activity. Results show 40-megacycle signals supported for 15 percent of time, while 80-megacycle signals dropped to less than 1 percent of time. As a test for solar origin of Es, the data were examined for recurrence tendencies in successive 27-day solar rotational periods. No pronounced recurrences of Es at 27-day intervals are apparent, from which it may be inferred that Es has no direct relationship with other recurrent solar phenomena such as sunspots and other centers of solar activity. Comparisons between Es and magnetic activity do not reveal any tendency of Es to be more prevalent during periods of magnetic disturbance.
A

WELLS, H.W., J.M. Watts, and D.E. George. Detection of rapidly moving ionospheric clouds. Phys. Rev. 69, 540-541 (1946).

Rapidly moving ionospheric clouds were detected in the earth's outer atmosphere (ionosphere) during the magnetic storm March 25-26, 1946, at the Kensington Ionospheric Laboratory, Department of Terrestrial Mag-

netism, Carnegie Institution of Washington. The clouds move in from long to short range or out again in intervals of few minutes. They are first detected at maximum ranges of 800-900 km. They are tracked inward at velocities of 1 to 2 km per second to F-layer levels (300-400 km). Occasionally they are seen to move out again at about the same rate. They are observed both during the night when background ionization is low and during the day when background ionization is high. Angle of arrival of the signals cannot be ascertained by the method employed.

These clouds were observed repeatedly during the interval $15^{h}00^{m}$, March 25, to $07^{h}00^{m}$, March 27, 1946 – the first opportunity for application of the new recording technique to observation of magnetic-ionospheric storms. The observations were made with the new "panoramic" ionospheric recorder, developed with support of the United States Signal Corps which sweeps over the range, 1.5 to 20.0 Mc/sec. at adjustable intervals of 5 to 30 seconds. Repetition at such short intervals registers ionospheric fluctuations of short duration which have been missed by earlier instrumentation. The technique has been perfected to the extent that successive records can be projected as motion pictures. Compression of the time-scale as a result of projection provides a sense of continuity which simplifies visualization and interpretation of an otherwise long succession of events.

The panoramic sweep is displayed on a cathode-ray tube and records are made automatically by successive exposures of single frames of film for each sweep. Examples of normal records with 15-second sweep at 30-second intervals for three minutes are illustrated in Fig. 1* while rapidly changing disturbed conditions are illustrated in Fig. 2*. Although illustration of a cloud tracking is not immediately feasible, Fig. 2 serves to demonstrate the rapid changes which may occur in a 30-second interval between exposures. Both figures are enlarged from 16-mm film. The parallel horizontal lines are height-markers at 50-km intervals upward from the base-line at 0-km and the "pips" at top of record are frequency-markers at 1-Mc/sec. intervals with increasing frequency from left to right. In the figures the visible range is from 1.5 to 14 Mc/sec. The total elapsed interval in each case is three minutes with time progressing downward from top to bottom.

The principal effects of influx of the clouds are: (1) sudden changes in F-layer ionization; (2) rapid changes in F-layer heights indicating turbulence which is often progressive from high to low heights and from high to low frequencies; (3) rapid fluctuations of echoes at the lower frequencies with occasional temporary disappearance indicating high absorption.

* FIGS. 1 and 2. (1) Six successive normal ionospheric 15-sec. records during three minutes afternoon March 19, 1946; (2) six successive disturbed ionospheric 15-sec. records during three minutes of magnetic storm, March 25, 1946, showing rapid changes. (Records are reproduced from original 16-mm film; height-markers are at 50-km intervals, frequencies are indicated from 1.5 to 14 Mc/sec.)

We are inclined to attribute these clouds to an inflow of corpuscles which are bombarding the atmosphere in an irregular manner during magnetic disturbance. These probably are the first direct quantitative observations of such bombardment. They are interpreted as establishing that corpuscular radiation contributes to the net ionization of the F-region. The equivalent maximum electronic density is estimated from magneto-ionic theory to be 2 to $4X10^5$ electrons per cc. Much of the uninterpreted scatter of the disturbed F-region previously seen on slow recorders can doubtless be traced to chance registration of various aspects of rapidly moving clouds. It is considered probable that other higher velocity cloud movements exist which will be detected by even faster recordings.

The new technique of ionospheric recording and presentation provides a very powerful tool for study of special ionospheric features which occur during magnetic storms, eclipses, radio fade-outs, sporadic E, F2 scatter, and abnormal stratifications. Projection makes possible quick scanning of an enormous wealth of data, selection of portions for critical study, and visualization of dynamic events of short duration.
Excerpt

WELLS, H.W. and L.V. Berkner. Ionospheric research at Huancayo Observatory, Peru, Jan. 1938 - June 1946. Publication 175, Carnegie Institution, Washington, D.C. (1947).

No abstract available.

WELLS, H.W. F-scatter at Huancayo, Peru, and relation to radio star scintillations. J. Geophys. Res. 59, 273-277 (1954).

The scattering of radio waves by the F-region of the ionosphere at an equatorial location (Huancayo, Peru) was discussed by Booker and Wells (1938). Subsequent analysis reveals pronouncedly diurnal, seasonal and annual characteristics. It is fundamentally a night-time event, with greatest frequency of occurrence in the period from four hours before midnight to four hours after midnight. The scattering is most prevalent during seasons when the sun is overhead and is infrequently observed during May, June, July and August (local winter) when the noon solar zenith angle becomes as great as 35°. The relative total annual occurrence of F-region scatter for the period 1938 through 1945 shows low values during 1941-1942, followed by a rapid increase through 1946, which is not closely related to solar activity. The diurnal properties of F-scatter closely correspond to reported characteristics of radio star scintillations with peak activity around midnight. However, the annual or seasonal properties are not in simple agreement.
PA

WHALE, H. A. Widespread diurnal variations of effective slope of the ionosphere. Nature 175, 77-78 (1955).

Bearing and elevation of radio signals from Fiji and Brisbane, received at Seagrave, Auckland, are used to determine daytime diurnal variation of the effective N - S and E - W slopes of the ionosphere.
N

WHALE, H. A. Effective tilts of the ionosphere at places about 1000 km apart. Proc. Phys. Soc. B69, 301-310 (1956).

Observations of bearing and elevation of signals received at Auckland, N. Z., from Fiji (9315 Kc/s, distance 2000 km) and Brisbane (9660 Kc/s, 2250 km) are sometimes consistent with the existence during the daytime of effective ionospheric tilts which are similar at places more than 1000 km apart. These tilts are of the order of half a degree and are in opposite directions during the morning and the afternoon. They may correspond to actual tilts of a uniform ionosphere or be due to horizontal gradients of electron density.
N

WHITEHEAD, J. D. The absorption of short radio waves in the D-, E- and F-regions of the ionosphere. J. Atmos. Terrest. Phys. 16, 283-290 (1959).

The published values of the noon absorption of radio waves of frequencies 2, 2.4, 4 and 4.8 Mc/s measured at Slough from 1947 to 1953 have been analysed. From the absorptions of 2 and 2.4 Mc/s waves, it has been deduced that (a) the electronic collision frequency v_0 at the height of the maximum electron density in the E-region when the sun's rays are incident vertically on the ionosphere is $(1.9 \pm 0.?) \times 10^4$ per sec; and (b) the normal absorption in the D-region increases with increasing sunspot number, whereas the additional absorption which occurs on certain winter days and arises in the D-region may decrease with increasing sunspot number.

The 4 and 4.8 Mc/s waves were reflected from the F-region at noon. The absorption in the F-region is calculated from the known total absorption and the calculated absorption in the D- and E-regions. The collision frequency in the F-region may then be found. At the height of reflection of 4 Mc/s waves (150 to 180 km) it is $(3.6 \pm 0.6) \times 10^3$ per sec, and at the height of reflection of 4.8 Mc/s waves (180 to 200 km) it is $(3.0 \pm 0.6) \times 10^3$ per sec. The significance of these results is discussed.
A

WHITEHEAD, J. D. The formation of a sporadic-E layer from a vertical gradient in horizontal wind. IN: Smith, E. K., and S. Matsushita, eds., 276-291 (Macmillan Company, New York 1962).

A horizontal wind shear leads to vertical movement of ions and electrons, which gives rise to the formation of thin layers of ionization. The probability of the layer appearing depends on the horizontal component of the earth's magnetic field. This is the same as the probability observed for sporadic-E critical frequency (f_oE_s) to exceed 5 Mc/s in different parts of the world. The hypothesis that all temperate zone sporadic E is due to horizontal wind shears is given further support because it shows how sporadic E once formed will tend to persist, gives the correct height at which the layer is most likely to form and is satisfactory so far as orders of magnitude of the various quantities are concerned. It also leads to an explanation of the relationship between the F-region travelling disturbances and sporadic E.

The electron density distribution arising from the vertical movement is discussed, taking into account recombination and diffusion.

The magnetic effects of sporadic-E clouds are discussed.

A

WHITEHEAD, J. D. Theory of equatorial sporadic-E. J. Atmos. Terrest. Phys. 25, 167-173 (1963).

It is shown that when sound waves travel at right angles to the magnetic field in the lower E-region near the earth's magnetic equator, marked build-up of electron density irregularities is possible. The theory indicates that whilst the electron density irregularities may be much more intense than the corresponding air density variations, they are nevertheless related and no instability process leading to strong irregularities is required. Thus the irregularities may result in only weak scattering of radio waves, as is observed. The irregularities tend to form at a rather definite height near the magnetic equator, and are strongly dependent on the magnitude of the equatorial electrojet current. The minimum transverse size of irregularities is a few metres and they move at right angles to the magnetic field with the velocity of sound. All these properties appear to be in accord with observation and strongly suggest that this is the means by which equatorial sporadic-E is produced.

PA

WHITEHEAD, J. D. The density of the atmosphere in the E-region of the ionosphere. Planet. Space Sci. 11, 513-521 (1963).

Estimates of the density of the atmosphere in the E-region of the ionosphere using a variety of techniques range over a factor of about 30.

Current models likewise give values ranging over a factor of six, and it is of interest therefore to compare the various estimates and assess their reliability. The methods considered are direct density or pressure measurements by gauges and mass spectrometers carried in rockets, the measurement of X-ray fluxes, the diffusion of artificial sodium clouds and meteor trails, densities deduced from electron collision frequencies, and from an estimate of ion collision frequency from a sporadic E-region study. The evidence suggests that the latest gauge results are likely to be the most reliable of these but the study points the need for a special low orbiting satellite to measure this important parameter in E-region.
A

WHITSON, A. L., W. T. Sperry, and F. H. Smith. A summary of literature pertaining to VLF and ELF propagation. SRI Project 3311, Contract SD-66, Stanford Research Institute, Menlo Park, Calif. (July 1962).

A bibliography of the literature pertaining to VLF and ELF propagation is presented. Author's abstracts are given whenever they were available. The survey includes theory, measurements, the transmission medium (ground constants and lower ionosphere), atmospheric noise, and extra-terrestrial VLF and ELF phenomena (whistlers, hiss, etc.).

Note: An index to this bibliography by A. L. Whitson was published separately as Vol. III (Dec. 1963).

A

WILD, J. P. and J. A. Roberts. The spectrum of radio-star scintillations and the nature of irregularities in the ionosphere. J. Atmos. Terrest. Phys. 8, 55-75 (1956).

An observational study of the spectrum of radio-star scintillations has been made with a view to exploring the small-scale structure of the ionosphere. Observations of the intense source in Cygnus were made near transit at an altitude of about 15°. Three instruments were used simultaneously: (1) a swept-frequency spectroscope to record the dynamic spectrum of scintillations, (2) a swept-frequency interferometer to study positional deviations at different frequencies, and (3) a triangular spaced-

aerial system for studying the lateral size and motion of the pattern on the ground.

The commonly occurring types of dynamic spectra are described, and their interpretation in terms of ionospheric phenomena is discussed. From the nature of the spectra it is inferred that most of the fluctuations are due to focusing by single lens-like irregularities, rather than to diffraction at a large number of irregularities. The spectra also show that the scintillation patterns are often dispersed across the ground, different frequencies being focused at different points. This is tentatively attributed to ionospheric gradients which act like huge prisms. Such "dispersing regions" may lie at different levels from the "focusing regions."

The degree of fluctuation shows two maxima, one near midnight (winter) and the other near midday (summer). The size, shape, and motion of the pattern on the ground, as well as the dispersion, also vary throughout the year.

In many cases the pattern on the ground is highly elongated, a feature which complicates the determination of the direction and speed of motion. For daytime conditions at least, this elongation indicates marked anisotropy in the ionospheric irregularities.
A

WILD, J. P., and J. A. Roberts. Regions of the ionosphere responsible for radio star scintillations. Nature 178, 377-378 (1956).

There is at present conflicting evidence as to the region of the ionosphere which is responsible for the scintillation of radio stars. Thus workers in the northern hemisphere observing sources at fairly high angles of elevation, and also Mills and Thomas in the southern hemisphere observing the Cygnus source at an altitude of 15°, have found a marked correlation between the occurrence of scintillations and of spread F echoes. On the other hand, Bolton et al. at the same southern location as Mills, but observing sources within 10° of the horizon, found an equally marked correlation with sporadic E, but not with spread F.

We report here an analysis of some recent observations of scintillations, which appears to offer a solution to this problem. We find a correlation of night-time scintillations with spread F only, and of daytime scintillations with sporadic E only.

In the observations referred to, the source Cygnus A was observed from Dapto, New South Wales (lat. 34° 28.5' S., long. 150° 47.5' E.). The observations were restricted to ± 1 hr. from transit, when the altitude of the source is 15°. As reported earlier, the prevalence and intensity of scintillations vary markedly from day to day, but show two well-defined maxima, one when transit occurs near mid-day (December, summer), and one when transit occurs near midnight (June, winter). We are unable to determine whether these variations are diurnal or seasonal: for brevity, we shall refer to them as if they were diurnal.

In view of the occurrence of two such distinct maxima in the fluctuation index, the correlation between scintillations and ionospheric phenomena has been studied for day and night periods separately.

Day-time scintillations. Rays from Cygnus penetrate the F region (400-km. level) approximately 650 km. south-east of Townsville and 400 km. north-west of Brisbane where routine ionospheric recorders are located. At no time during our day observations were spread F echoes reported from either of these stations.

For the E layer, the point of penetration lies 500 km. south-southwest of Brisbane and 500 km. north-north-east of Canberra, the nearest ionospheric recording stations. Table 1, which compares the sporadic E observed at these stations with the occurrence of scintillations, shows that the two are closely associated. There is a marked tendency for high fluctuation indices to occur when the critical frequency of sporadic E echoes is high. When the data are tested by either the X^2 or the "exact" test, it is found that the probability of the observed values occurring by chance if the two phenomena are independent is less than 1 in 10^4.

Because of the patchy nature of sporadic E, we have included in Table 1 only those days for which values of fEs (or fE2s) were available from both Brisbane and Canberra and for which either: (a) no value of fEs (or of fE2s) in excess of 5 Mc./s. was found at either of these stations during our observing period, or (b) a value of fEs (or of fE2s) greater than 5 Mc./s. was recorded at both stations during our observations. The value 5 Mc./s. was chosen to divide the data into approximately equal parts: similar considerations decided the grouping of fluctuation indices used in Table 1.

Night-time scintillations. For night-time scintillations the correlation with spread F at Townsville is given in Table 2. In this case there is clearly a close association between the occurrence of high fluctuation indices and the appearance of spread F. According to either of the statistical tests mentioned, the probability of the figures occurring by chance alone is less than 1 in 10^6. There is a similar, but rather weaker, correlation with spread F at Brisbane.

The results for sporadic E are given in Table 3, which shows no evidence of any correlation with night-time scintillations. Here 3 Mc./s. has been taken as the dividing value of fEs, again on the basis of separating the data into approximately equal parts. Other values were tried, and also other groupings of the fluctuation index, but none showed any evidence of a correlation between the two phenomena. The probability of figures such as those in Table 3 occurring by chance in uncorrelated data is about 0.6.

These results suggest that night-time scintillations arise in the F-layer and day-time scintillations in the E-layer. They are consistent with the observation that, at night-time only, there is a pronounced west-to-east component (some 80 m. sec.$^{-1}$) in the motion of the

scintillation patterns across the ground. Such a motion would be caused by the Earth's rotation if the irregularities were located at a height of about 500 km. and did not drift. It may also be noted that the current conception of sporadic E irregularities in terms of thin horizontal strata is in agreement with the fact that day-time scintillations have been reported only by workers observing at relatively low angles of incidence.

The ionospheric data for this analysis were taken from "Ionospheric Predictions, Series D", supplied by courtesy of the Ionospheric Predictions Service of the Australian Commonwealth Observatory.

WOODWARD, R.H. A model of the ionosphere. Terres.. Mag. Atmos. Elec. 53, 1-25 (1948).

Observations and theories of a number of geophysical phenomena associated with the ionosphere are summarized, and a model proposed to provide qualitative interpretations of most of them. In low and intermediate latitudes electrons are assumed to rise; they migrate through the upper ionosphere to the polar region, where they fall and complete the circuit through the ground. Under the action of an electric field, positive ions, formed at great heights by u.v. light, tend to rise, whereas negative ions descend. Since the ions are constrained to helical paths along the sloping magnetic lines of force, positive ions tend to collect in a ring near the plane of the geomagnetic equator; negative ions accumulate in the polar regions. Solar radiation-pressure distorts the ion-ring and blows the tail to a height of several Earth-radii. Electric discharges between the positive ion-ring and the negative polar caps produce magnetic disturbances and the associated auroral displays.
PA

WRE. Ionospheric data for Feb. 1962 from Woomera, South Australia. Weapons Research Establishment, Australia (May 1963).

Tables of the hourly values of the customary ionospheric parameters are given for the station at Woomera for February, 1962.
STAR

WRIGHT, J.W. Note on quiet-day vertical cross sections of the ionosphere along 75°W geographic meridian. J. Geophys. Res. 64, 1631-1634 (1959).

Programs are now under way at several institutions for the systematic reduction of ionospheric vertical soundings to electron density profiles, N (h) curves, thereby making available for the first time adequate numerical data on electron densities throughout the lower ionosphere at many dates, times and places [see Thomas (1959) for a comple bibliography of work in this field]. In undertaking a similar program, the National Bureau of Standards has had two immediate objectives: to develop efficient methods by which hourly ionospheric soundings may be systematically reduced to N (h) profiles from a number of sounding stations, making these data available regularly to research workers; and to carry out a study of ionospheric morphology along a chain of stations stretching nearly from pole to pole along the 75° W geographic meridian. It is planned to combine these objectives by concentrating a systematic hourly reduction program on the 75th meridian stations. Already, stations at Fort Monmouth, New Jersey; Grand Bahama Island; St. Johns, Newfoundland (U. S. Army Signal Corps); and Puerto Rico (NBS), are preparing hourly virtual height data in the form required for N (h) analysis.
Excerpt

WRIGHT, J.W. A model of the F region above $h_{max}F2$. J. Geophys. Res. 65, 185-191 (1960).

A simple Chapman model (scale height 100 km) of the ionosphere above the peak of the F region is found to be in good agreement with the few observed profiles of this region. The ratio of the above-peak electron content implied by the model to below-peak electron content is found to vary from about 2.8 to 4.0, also in good agreement with observations. The model is used in conjunction with electron density profiles observed from the ground to construct meridional cross sections along the 75° W geographic meridian.
A

WRIGHT, J.W. Vertical cross sections of the ionosphere across the geomagnetic equator. NBS Tech. Note 138, National Bureau of Standards, Boulder, Colo., 1-8 (1962).

Contours of ionization along a meridian crossing the geomagnetic equator are shown for each hour of a quiet period in March 1958. The equatorial ionospheric anomalies are thereby illustrated and discussed phenomenologically. The probable physical processes are described.
MGA

WRIGHT, J.W. The F-region seasonal anomaly. J. Geophys. Res. 68, 4379-4381 (1963).

In one of its most consistent contradictions of the simple and intuitively reasonable "Chapman" theory, the daytime ionospheric F_2 layer is found to contain much more ionization in the winter season than in summer. Perhaps because the period of high electron densities is confined to only a short midwinter period, this "seasonal" anomaly is also called the "winter" anomaly; however, so far there seems to have been little basis for deciding whether the winter densities are anomalously high, or whether the summer densities are anomalously low. Since the processes controlling the anomaly are presumably intimately related to the essential equilibrium of the ionosphere, it is important that such an anomaly be expressed in other than purely relative terms. In this note we shall demonstrate that in the morning hours the F region at low midlatitudes does not show a seasonal anomaly and that its behavior versus the solar zenith angle is identical with that in the winter at higher latitudes. A departure from this law develops progressively with increasing latitude in the summer season. The hours between sunrise and noon are those in which height-integrated electron production (which varies as $\cos\chi$, where χ is the solar zenith angle) tends to dominate other processes (e.g., electron loss and plasma diffusion). Thus there is at least a qualitative meaning to the extent to which the F-region electron densities in the morning hours increase with $\cos\chi$.

The seasonal anomaly is well known from measurements of the F-region maximum electron density (N_{max}), and is shown more fully, together with other variations, by Wright (1962). It is evident in the lower part of Figure 1, where the monthly mean values of N_{max} for the morning hours are shown versus their respective $\cos\chi$ over a period of one year. The variation is shown for Puerto Rico (geomagnetic latitude 18.5° N, magnetic dip 51.5° N) and for Newfoundland (geomagnetic latitude 47.5° N, magnetic dip 72° N). Winter values exceed the summer values by a considerable amount, and the equinox periods are in between, despite the lower values of $\cos\chi$ in the winter.

The electron content (per centimeter column) below the peak of the F_2 layer, obtained by integration of electron density profiles, is used here to characterize the electron density variations of the F region. Monthly mean values of this quantity (termed Sh_{max}), excluding those hours where $K_p \geq 4+$, are available from six ionospheric stations between 18° N and 52° N, over the same period as that shown for N_{max} in the figure. In the top part of Figure 1, these values of Sh_{max} are shown versus their respective values of $\cos\chi$ for the same two stations as shown for N_{max}. The seasonal anomaly in Sh_{max} is less evident than in N_{max} at Newfoundland, but it is entirely absent in the

Puerto Rico values of Sh_{max}. Furthermore, the seasonally consistent variation of Sh_{max} with $\cos\chi$ at Puerto Rico is obeyed by the winter values at Newfoundland, as is shown by the broken lines in these diagrams. This same behavior occurs at each of the six stations for which data are available.

The character of the anomaly is more fully illustrated by Figure 2, where the $\chi = 0$ intercepts for the summer and winter values are shown versus latitude for each of the six stations. Data are shown for two years, 1959 and 1960, for which the smoothed Zurich sunspot numbers range between 130 and 180 and between 80 and 130, respectively. It is clear that the winter values in both years are substantially independent of latitude, whereas the summer values decrease markedly with increasing latitude. During 1960, the $\chi = 0$ electron content is lower, in about the same proportion, both summer and winter. The difference between summer and winter is, however, disproportionately larger at the lowest latitude during 1960, the year of lower solar activity.

In view of this behavior, it is evident that the summer should be considered the anomalous season, rather than the winter. It is, in fact, rather easy to conceive of processes that could reduce the summer electron content, whereas it has proven difficult to find a sensible process which could enhance markedly the winter values. Two explanations, which will only be mentioned here, are possible either separately or in combination: (a) the proportion of molecular nitrogen to atomic oxygen may be increased in the summer, relatively more of the ionizing radiation then being absorbed by N_2. The electrons associated with ionization of N_2 disappear very quickly by dissociative recombination, and hence contribute but little to the observed F-region electron densities (Bates, 1951; Nicolet, 1959). (b) The rate of loss of electrons may be increased in the summer, as the result of an increase of the N_2/O and O_2/O ratios. Ultimately, the rate of electron loss depends on secondary processes such as $O^+ + N_2 \rightarrow NO^+ + N$, and $O^+ + O_2 \rightarrow O_2^+ + O$, after which dissociative recombination of the electrons with either molecular ion proceeds rapidly. These processes have been suggested by Rishbeth and Setty (1961) to explain the seasonal variation in the rate of increase of electron density just at sunrise. Thus, although a dependence of N_{max} on magnetic dip has been pointed out by Croom et al. (1960), the summer anomaly may find its explanation in a seasonal variation in the composition of the upper atmosphere.

WRIGHT, R.W., J.R. Koster, and N.J. Skinner. Spread F-layer echoes and radio-star scintillation. J. Atmos. Terrest. Phys. 8, 240-246 (1956).

Observations of radio-star scintillations made at University College of the Gold Coast, Achimota, and spread F-layers made at University College, Ibadan, Nigeria, have been compared. Considerable correlation is found, although there is 510 km between the two stations, and the ionospheric observations are made entirely at vertical incidence. The diurnal and seasonal variations of the presence of spread F-layers are examined. It is found that these depend considerably on the degree of magnetic disturbance. In particular, at Ibadan in winter on disturbed days there is only a quarter of the scatter that occurs on quiet days.
A

WRIGHT, R.W. Geomorphology of spread F and characteristics of equatorial spread F. J. Geophys. Res. 64, 2063-2065 (1959).

The characteristics of spread F in the magnetic equatorial zone were outlined, and evidence of vertical velocities, retardation and loss of stratification in the later evening, and negative correlation with magnetic activity was presented. It was also noted that radio-star scintillations and rapid fading of long-distance, high-frequency transmissions in equatorial regions show very similar variations and correlation. Spaced receiver measurements were reported that indicate highly elongated, field-aligned irregularities in the equatorial F layer. (See paper under same title, this symposium.)
A

WRIGHT, R.W., and N.J. Skinner. Lunar tides in the sporadic E-layer at Ibadan. J. Atmos. Terrest. Phys. 13, 217-221 (1959).

An analysis of the lunar semi-diurnal tides in fEs and h'Es is made for Ibadan. The results are presented in the form of harmonic dials. Comparisons are made between these results and those of other stations.
A

WRIGHT, R.W., and N.J Skinner. Equatorial spread F. J. Atmos. Terrest. Phys. 15, 121-125 (1959).

Spread-F conditions have been examined for six low-latitude stations—Dakar, Khartoum, Djibouti, Ibadan, Nairobi and Leopoldville.

It is shown that, contrary to the general view, occurrence of disturbed magnetic conditions inhibits the occurrence of spread-F layers

during the southern solstice at all these stations. The seasonal variation of the occurrence of spread-F is considerably changed if, instead of all days, only magnetically quiet days are considered.

In the northern winter there appears to be widespread correlation of occurrence of spread-F across Africa. This is shown to be due to the magnetic influence.

A

WRIGHT, R.W. Geomorphology of spread F and characteristics of equatorial spread F. J. Geophys. Res. 64, 2203-2207 (1959).

Between magnetic latitudes 20°N and 20°S there is a well defined region where spread F is a normal occurrence on magnetically quiet days. Equatorial spread F is a night-time phenomenon that begins between 1900 and 2200 by a characteristic doubling of the layer and an increase in virtual height, indicating a vertical velocity. Later in the night, after 2300, the records show group retardation and no stratification. The occurrence of equatorial spread F is decreased by magnetic activity.

Radio-star scintillations in equatorial regions are correlated strongly with spread F and have the same diurnal variation and the same anticorrelation with magnetic activity. The phenomenon of "flutter" (rapid fading of long-distance, high-frequency stations) shows the same variations. Measurements using the spaced receiver method indicate that, in the equatorial region, the irregularities in the F layer are greatly elongated along the lines of the earth's magnetic field.

A

WRIGHT, R.W., A.J. Lyon, and N.J. Skinner. The morphology of spread-F. Ann. IGY, 1957/1958, 11, 253-257 (1961).

The so-called "spread-F" condition is a world-wide phenomenon observed at all latitudes. It was previously shown that there is a marked difference in incidence of spread-F between equatorial and temperate latitudes. It is the purpose of this note to investigate the incidence of spread-F on a world-wide basis and to demarcate the regions where the correlation with magnetic activity is, respectively, positive and negative. After a rather detailed analysis of routine tabulations, the authors conclude that equatorial type spread F is characterized by the fact that 1) it is normally present on magnetically quiet days; 2) its occurrence is normally reduced on magnetically disturbed days; 3) it exists in a belt from approximately 23°S to 23°N geomagnetic lat. Subject Headings: 1. Spread F 2. Geomagnetic-ionospheric relationships.

WRIGHT, R.W.H. Geographical extent of Es-q layer in Africa. IN: Semi Annual Report to Voice of America, Part B, Africa Ionosphere, 155-157 (July 1962).

The National Bureau of Standards has a contract with the University of Ghana to carry out measurements intended to increase the knowledge of behavior of Sporadic-E around the magnetic equator in West Africa. The specific aim is to determine the distribution of equatorial Sporadic-E with latitude. Since this type of Sporadic-E occurs during many of the daylight hours in this area it has a marked effect on propagation conditions. The following report taken from a letter written by Professor R. W. H. Wright of the University of Ghana to Dr. Kenneth Davies of the NBS describes the Equatorial Sporadic-E Program sponsored by NBS in Ghana. It is included here because of the Voice of America interest in this geographical area.
Excerpt

WRIGHT, R.W. Effect of magnetic disturbances on the equatorial ionospheric jet current. Nature 194, 1169-1170 (1962).

The daily variations of the geomagnetic field components near the magnetic equator are studied for quiet and disturbed conditions. It is suggested that the location of the jet current is affected by magnetic disturbance.
PA

WRIGHT, R.W.H. Equatorial study of irregularities in the ionosphere. Summary Rept. 1, Oct. 1960-Sept. 1961, Contract AF61(052)421, Ghana University, Africa (28 Jan. 1962). AD-289 404.

DDC

WRIGHT, R.W.H., and F. Hibberd. Preliminary report on recent measurements to determine the width of the equatorial sporadic-E layer. J. Geophys. Res. 68, 2527-2528 (1963).

Between April and August 1962 a temporary ionospheric station was established in turn at four points lying roughly on a north-south line in the neighborhood of the magnetic equator, while a permanent station operated at Accra. Figure 1 shows the stations and the position of the magnetic equator; details are listed in Table 1. Both ionosondes were Canadian Cossors used with a vertical delta aerial.

Normal ionograms were taken every hour. In addition, every 5 minutes for half an hour on either side of noon, a record was made showing the strength of the echoes received on a fixed frequency from

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the E_s layer and the F layer. The fixed frequency was 4.42 Mc/s, well above the critical frequency of the E layer, f_oE.

This report is restricted to a preliminary analysis of the normal ionograms obtained. Moreover, the analysis has been even further simplified by considering each ionogram from the point of view of the presence or absence of q-type sporadic-E-layer reflections.

Figure 2 is a contour map drawn from the percentage of days on which E_{sq} occurred at each station, at the given time. We have been able to deal only with one side of the E_{sq} belt, and it is necessary to assume the symmetry of the belt about the magnetic equator to indicate the belt width.

TABLE 1

Site	Magnetic Latitude	Distance from Magnetic Equator, km	Length of Observation
Tamale	0° 22'S	40	24 days
Salaga	1° 13'S	135	16 days
Atebubu	2° 01'S	220	16 days
Kumasi	3° 05'S	340	16 days
Accra	4° 08'S	455	Continuous

It will be seen that, even with such limited data and such a simple analysis, the belt is quite apparent. A consistent belt of half-width 3° of magnetic latitude, about 300 km, has 100 percent occurrence of E_{sq} between the hours of 0830 and 1330 GMT (local time is very close to GMT). Consequently we would suggest that the full belt is about 600 km wide for the regular appearance of E_{sq} between those hours, and its length would be approximately 75° of longitude.

We emphasize that these conclusions can be considered to apply only during the period that the measurements were made; the belt may vary at different seasons, at different times of the sunspot cycle, and under different conditions of magnetic activity. We are analyzing the other results further, to obtain a more sophisticated measure of the intensity of E_s present.

Excerpt

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YACOB, A. Some features of magnetic elements at Trivandrum and Annamalainagar, situated near the geomagnetic equator in the Indian Peninsula. Indian J. Met. Phys. 10, 377-392 (1959).

The Sq diurnal variation in H at Trivandrum and Annamalainagar are found to be large compared with those at Alibag. The quiet day range in H at Trivandrum in the month of March is abnormally large. Though the Sq variations in V at Trivandrum are not abnormal they are larger than those at Annamalainagar and Alibag.

The response of the H elements to disturbance at Trivandrum, Annamalainagar as well as Alibag are similar in sense. But the V element at Annamalainagar shows a difference in its response to disturbance. When the V elements at both Alibag and Trivandrum show an increase in numerical magnitude the V element at Annamalainagar shows a decrease and vice versa.

When the magnitudes of disturbance are examined they are found to be almost the same in the H element at all the observatories (including Alibag) during night hours. But during the day the magnitudes of disturbance in H element at Trivandrum and Annamalainagar are always greater than that at Alibag, a station away from the geomagnetic equator. Effects of disturbance in the V element are greatest at Trivandrum both during the day as well as the night.

The lines of force of an average disturbance field in a longitudinal plane over the region of the Indian Peninsula appear to be smooth curves with their concave side turned upwards, their turning points occurring between Annamalainagar and Alibag during the day and close to Alibag in the night.

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YAMADA, K., and T. Ogata. Ionosphoric observation under the solar eclipse in East New Guinea on 5 Feb. 1962. J. Radio Res. Labs. Japan 10, 287-310 (July 1963).

This observation was made with the aid of an ionosode of portable type at Lae in East New Guinea. Effects of the solar eclipse on the ionosphere were recognized in variations of the critical frequencies and virtual heights of E, F1 and F1 1/2 layers. The values of electron density obtained from the critical frequency were compared with those calculated from the fundamental formula based on Chapman's distribution and those at various heights obtained from the N (h) proviles, in order to obtain the recombination coefficient and attachment coefficient at various heights of each layer.

These values agreed fairly well with those reported hitherto. The variation of electron density in the lower part of the ionosphere during the eclipse was quite different from the values calculated from the fundamental formula because of the non-uniformal radiation of the solar disk. Since a great condensation of corona, however, was reported in the western limb of the solar disk, calculation considering the effect of this condensation gives an agreeable result. The variation of electron density at a height above 350 km and in the F2 layer was not remarkable during the solar eclipse. Investigation of variation in attachment coefficient with the height brought to light the scale height, and the temperature of the upper atmosphere was calculated by the use of the value of the scale height. The temperature of the upper atmosphere at a height of 300 km was 940°K almost the same as above Antarctica in the winter season, or a little lower than above Antarctica where the ionospheric observation has been made during the eclipse before.
PA

YAMAMOTO, M., and H. Maeda. The simultaneity of geomagnetic sudden impulses. J. Atmos. Terrest. Phys. 20, 212-215 (1961).

Investigations on the degree of simultaneity of the geomagnetic-storm sudden commencement have recently been made by Gerald (1959) and Williams (1960) on the basis of IGY data, and their results were somewhat different. The purpose of this note is to find a key for the solution of the problem of whether or not geomagnetic sudden impulses and sudden commencements are essentially the same, and if they are the same, how they occur.

We used copies of quick-run magnetograms during the IGY from various stations for four sudden impulses which occurred on 14 October 1957, 12 February, 21 July and 11 November 1958, because they could be easily measured. The stations are: Leirvogur, Nurmijärvi, Lovö, College, Big Delta, Point Barrow, Healy, Sitka, Fredericksburg, Tucson, Shimosato, Honolulu, Koror, Guam, Wilkes, Little America, Apia and Scott Base. Measurements were confined to H-(or X-) traces alone, and when H-traces were unreliable, D-traces were used. In graphs (a)-(d) of Fig. 1 the order of occurrence of sudden impulses is plotted in a form similar, for the convenience of comparison, to that illustrated by Williams (1960). Geographic latitude, geographic longitude and the local time are given around each graph. On the right of the graphs are plots of the order of occurrence against time.

These analyses of the data yielded the following results:

(1) Time differences of sudden impulses around the earth were within 1 min;

(2) The sudden impulses always occurred first in high latitudes;

(3) The average propagation velocity of sudden impulses between Honolulu and Koror was about 1300 km/sec.

These results are very similar to those obtained by Williams (1960) for sudden commencements of magnetic storms. Further study is in progress, and its result will be published later.
Excerpt

YASUHARA, M., and H. Maeda. Geomagnetic crochet of 15 November 1960. J. Atmos. Terrest. Phys. 21, 289-293 (1961).

On 15 November 1960 a very strong solar flare was observed, and the accompanying geomagnetic crochet (or s.f.e.) was an unusually great one. The time of occurrence was about noon in Japan, Australia, and their neighbouring countries, where many geomagnetic stations were in operation, and so this strong flare offered us a good chance to study the properties of geomagnetic crochet.

The position of the flare on the solar disk was 26°N 33°W, and its importance was class 3+. It commenced at 0207 hours (U.T.) and reached maximum at 0221 hours. The ionogram at Yamagawa Radio Wave Observatory, Japan, showed a strong short-wave fade-out which commenced between 0215 and 0230 hours; meanwhile the receiving stations of solar radio emission at Tokyo and Toyokawa, Japan, recorded a predominant outburst of type IV beginning at 0221 hours (i.e. the time of maximum activity of the flare) as shown in Fig. 1

Figs. 2(a) and 2(b) show, respectively, the geomagnetic crochet recorded at Me, Ka, Ss, As, Ky, Ho, Gm and Mu in the northern hemisphere, and at Ap, Gn, To, Am and Mc in the southern hemisphere. The crochet commenced at 0220 hours and reached its maximum development at 0224 hours at many stations. Here we had some doubt as to whether or not the foregoing increase in H-trace which started at about 0208 hours was an effect of the flare. This variation, however, was omitted from the effect of the solar flare we are concerned with, because of the following reasons: (1) No distinct changes were noticeable until 0215 hours on the ionogram, and until 0221 hours on the dynamic spectrum of the solar radio outburst; (2) As the records from stations in the dark hemisphere showed another disturbance commencing before 0200 hours, this would also affect the sunlit hemisphere.

Fig. 3 shows the pattern of the electric currents flowing in the ionosphere, which are necessary to produce the horizontal component of the crochet at the time of its maximum development, where the arrows denote the geomagnetic disturbance vector at each station. As for Brisbane, on account of a lack of D-trace, and for Macquarie Island, because of the superposition of another disturbance owing to the locality in the auroral zone, the data of these two stations were only referred to. It is clear from the figure that the electric currents responsible for the crochet were unusually strong, roughly estimated as 250,000 A, and that the centre of vortex of the northern current was considerably shifted southwards. Although, because of the continuity of severe disturbances in November, it is not easy to deduce the normal S_q variation of the day concerned, yet, as compared with the standard S_q current system (Chapman and Bartels, 1940) it seems very likely that the electric currents responsible for the geomagnetic crochet should not be a simple augmentation of the S_q currents, as suggested by many workers hitherto (e.g. Grafe, 1958; Volland and Taubenheim, 1958; Veldkamp and van Sabben, 1960). Moreover, the following facts convince us that the geomagnetic crochet may be caused by the currents flowing mainly in the D-region.

Hachenberg and Krüger (1959) pointed out a close correlation between bursts of solar radio emission in the centimetre range with flares and sudden ionospheric disturbances (s.i.d.). On the other hand, it is now generally accepted that the s.i.d. is caused by an abnormal increase of ionization in the D-region by solar X-rays, and Chubb et al. (1957) actually observed the penetration of X-rays of 1 – 8 Å wavelength into the lower part of the D-region at the time of s.i.d. From these facts, a good correlation is also expected between solar radio outbursts in the centimetre range and abnormal increase in the radiation of solar X-rays. Fig. 1 shows a greater flux intensity in the centimetre range than in the metre range of solar radio emission. Thus it may be concluded that the considerably stronger penetration of solar X-rays into the ionospheric D-region had to exist at the time of maximum development of the solar flare, and it played an important role in the occurrence of s.i.d. and such a great geomagnetic crochet as dealt with here.

Now, from Fig. 3 we feel that it is difficult to agree with a view, which was emphasized by Veldkamp and van Sabben (1960), that the current pattern for geomagnetic crochets should be controlled by the magnetic (or dip) equator. However, further study of similar cases would give a clearer solution for this problem.

Excerpt

YEH, K. C., and O. G. Villard, Jr. A new type of fading observable on high frequency radio transmissions propagated over paths crossing the magnetic equator. Proc. IRE 46, 1968-1970 (1958).

Describes some observations in California of signals transmitted at 9.69 Mc/s by a B.B.C. station in Singapore. Under some circumstances it appears that the carrier energy is split into two independently fading components of comparable strength and separated by several tens of cycles. The weaker component beats with the stronger closely resembling a modulation of the latter. Fading characteristics and constancy of the beat frequency are discussed. It is suggested that the fading may occur as a result of the combination of conventional and tilt supported propagation across the evening equatorial height bulge.
EEA

YEH, K. C. Second-order Faraday rotation formulas. J. Geophys. Res. 65, 2548-2550 (1960).

Current observations of 20- and 40-Mc/s satellite signals have enabled us to determine the total electron content in the ionosphere using Faraday effect. Since the frequency is not very much higher than the plasma frequency in the ionosphere, the first-order theory (Browne, Evans, and Hargreaves, 1956) may be in appreciable error, owing to effects of refraction. The purpose of this note is to introduce a second-order theory in which the high-frequency approximation and the effect of refraction are taken into consideration. The resulting equations are easy to apply when observations are available on two frequencies, e.g., 20 and 40 Mc/s.

YEH, K. C., and O. G. Villard. Fading and attenuation of high-frequency radio waves propagated over long paths crossing the auroral, temperate and equatorial zones. J. Atmos. Terrest. Phys. 17, 255-270 (1960).

This investigation is primarily concerned with the fading and attenuation of high-frequency radio signals propagated over a long path crossing the auroral zone. The fading of high-frequency signals propagated over non-auroral paths of comparable length has also been studied, and some new results are obtained. The principal fading and attenuation measurements on which these conclusions are based were carried out in August 1957.

For the auroral paths, there is no diurnal variation in fading speed except for a distinct minimum in time interval 1330-1900 PST, during which time the fading speed has little apparent dependence on magnetic activity along the path. In other time periods a positive correlation

between magnetic activity and fading speed is found. It is suggested that the period of minimum fading speed is a consequence of the existence at that time of the kind of propagation mode made possible by ionospheric tilts.

Attenuation over the long auroral-zone path is found to be associated with "polar blackouts" as indicated by the absence of returned echo in vertical sounders located along the path. The percentage association varies with the location of the station relative to the path. This variation is consistent with the inferred propagation modes. It is found that during the hours 1330-1900 PST the attenuation cannot be attributed to the absorption that gives rise to blackouts as it can in the other hours. This is also explainable on the basis of the postulated tilt-mode propagation.

Similar observations for temperate-latitude and transequatorial paths of comparable length indicate that there is strong diurnal variation in fading speed. Some plausible explanations are offered.

YEH, K. C., and G. W. Swenson, Jr. Ionospheric electron content and its variations deduced from satellite observations. J. Geophys. Res. 66, 1061-1067 (April 1961).

A procedure is given for correcting the effect of refraction and the high-frequency approximation when Faraday rotation measurement is available on two frequencies. This method is used to analyze the records obtained on the ground of radio transmissions from satellite 1958 δ_2 (Sputnik III). The result reveals strong diurnal as well as anomalous seasonal variations. The depression in electron content during magnetic storms is identified, and the preliminary observational result is not inconsistent with the drift theory.

YERG, D. G. Notes on correlation methods for evaluating ionospheric winds from radio fading records. J. Geophys. Res. 60, 173-185 (1955).

A correlation method requiring six values of the correlation coefficient is developed. Expressions for the drift velocity, fading velocity, and characteristic velocity are obtained from a correlation theory extended to include an elliptical contour in the horizontal plane.

The physical significance of the derived velocities is considered. Preliminary data indicate that the correlation ellipse exhibits a preferred

orientation and that fading associated with random changes is as important as fading associated with a drifting pattern.

YERG, D. G. Observations and analysis of ionospheric drift. J. Atmos. Terrest. Phys. 8, 247-259 (1956).

Observations of radio fading at spaced receivers for 2·33 Mc/s and 4·57 Mc/s indicate that the ionospheric drift is more variable in winter than summer. Average speeds are 19 m/sec for 2·33 Mc/s records and 12 m/sec for 4·57 Mc/s records. Fading resulting from random changes is always significant. Random changes appear to be anisotropic and tend to rotate the correlation ellipse to a position along the magnetic field. The ellipse almost invariably is oriented with the major axis in the SW quadrant. The method of similar fades is less reliable than the correlation method in evaluating drift velocities and directions.
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YERG, D. G. Analysis of diffraction patterns on the ground caused by ionospheric irregularities. Scientific Rept. 1, Contract AF 19(604)3867, Michigan College of Mining and Technology, Houghton, Mich. (March 1961). AD-258 973.

Radio fading records obtained on spaced receivers for 2.33 mc/s at Mayagüez, Puerto Rico were made available for analysis. A method for determining the average drift velocity and the instantaneous normal departure velocity of the lines of constant signal intensity was developed and applied. The method also provides data related to the shape and orientation of the signal pattern. The procedure is based upon the evaluation of the space and time derivatives of the observed signal intensity. The results indicate differences in the dynamic characteristics of the signal pattern associated with day and night conditions. A sharp decrease in the drift speed is noted after midnight. The random motion of the ground pattern is anisotropic and is related to the anisotropy of the pattern. A sequence of short-period random pulses superimposed on a more or less regular fluctuation of longer period and smaller amplitude is indicated.
ASTIA

YONEZAWA, T. On the influence of electron-ion diffusion on the electron density and height of the nocturnal F2 layer (supplement). J. Radio Res. Labs. Japan 2, 281-291 (1955).

The previous consideration of the influence of electron-ion diffusion on the electron density and height of the nocturnal F2 layer neglected the effect of the earth's magnetic field and presumed that the atmosphere in the F2 region was composed of only one kind of molecules (or atmos). These assumptions have been examined from the standpoint of obtaining the lower limit to the atmospheric molecular density in the F2 region. It is shown that, while the existence of minor constituents in the atmosphere has no great influence on the conclusion, the effect of the earth's magnetic field may in the extreme case reduce the lower limits to about 60 percent of the former values, i.e. to as low as 3×10^9 cm^{-3}. But the scale height and atmospheric temperature giving this value seem to be not very probable and the value 5×10^9 cm^{-3} given in the previous paper will possibly be nearer to the truth. It is suggested that if the true height of the F2 layer is somewhere about 200 km, the discrepancy between this value and the extrapolation of rocket data will disappear.

YONEZAWA, T. New theory of the formation of the F2 layer. J. Radio Res. Labs. Japan 3, 1-16 (1956).

A new theory is proposed to the effect that in the lower portion of the F2 layer the height distribution of electron density is determined by electron removal due to its dissociative recombination with molecular ions of oxygen generated by the atom-ion interchange reaction between atomic ions and neutral molecules of oxygen, while in the upper portion it is determined by electron-ion diffusion in the earth's gravitational field, the maximum being produced at an intermediate height by both processes. The theoretical variations of the maximum electron density and of its height with latitude conform with observations fairly well except near the equator. The low-density (and low-temperature) model of the atmosphere based on rocket data seems to be preferable to the older model. The agreement with observations will become more satisfactory if electron-ion diffusion in the horizontal direction as well as the electric fields in the upper atmosphere and perhaps temperature effect are taken into consideration.
MGA

YONEZAWA, T. On the seasonal and non-seasonal annual variations and the semi-annual variation in the noon and midnight electron densities of the F2 layer in middle latitudes. II. J. Radio Res. Labs. Japan 6, 651-658 (Oct. 1959).

In continuation of the previous work, in which middle latitude stations as a whole were treated as one group, the noon and midnight electron densities of the F2 layer observed in middle latitudes have been subjected to a similar analysis, dividing the observational stations into two groups with relatively high or relatively low latitudes, in order to see if there exists any change with latitude. The average geographic as well as geomagnetic latitudes of the respective groups are about 47° and 27°. In general the results here obtained agree qualitatively with those obtained in the previous paper, but the following may be worthy of notice: (1) The seasonal variation in the noon electron density in relatively high latitudes is very different from that in relatively low latitudes. In the former region it is very marked and attains its maximum around December in a period of high solar activity, but it becomes much smaller and rather random in a period of low solar activity so that its amplitude and phase are not well-defined, while in relatively low latitude regions it is rather conspicuous in a period of low solar activity and reaches a maximum around June but becomes insignificantly small in a period of high solar activity. (2) There seems to be no very great difference between the non-seasonal variations at noon in relatively high and low latitude regions, but it may probably be concluded that the non-seasonal variation at midnight is larger in relatively high latitudes than in relatively low latitudes. (3) We do not find any very great and systematic difference between the semi-annual variations in relatively high and relatively low latitude regions except that they are generally larger in the latter regions. This component is generally larger in the southern than in the northern hemisphere, and the phase of this variation lags more or less behind in the periods when the sun is less active and/or in the case of midnight electron density.

YONEZAWA, T. The characteristic behaviour of the F2 layer during severe magnetic storms. IN: Proc. International Conference of the Ionosphere, London, July 1962, 128-133 (The Institute of Physics and The Physical Society, London, 1963).

Characteristic behaviour of the F2 layer during severe magnetic storms, consisting of a sudden increase in height and a simultaneous sudden decrease in electron density followed by a more gradual recovery, observed at Kokubunji during the IGY has been considered and it is concluded that this behaviour can be reasonably well interpreted in terms of heating of the upper atmosphere which brings about enhancement of

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chemical reactions there. From analysis of observational data, temperature variations of the upper atmosphere and the average activation energy of the chemical reactions can be roughly inferred. The latter has been found to be of the order of a fraction of one electron volt.

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ZACHARISEN, D. H. Time and distance correlation study of F_2 layer ionosonde data. IN: Semi-annual Report to Voice of America, NBS Rept. 7696, National Bureau of Standards, Boulder, Colo., 31-36 (July 1963).

This report is a continuation of a pilot study reported on in the last Semi-Annual Report to the Voice of America (NBS Report No. 7621). The ionosonde stations that have been used in this study have been limited to those for which the data have been punched on IBM cards for IGY World Data Center A. Most of these data are limited to the periods July 1957 to December 1958 and July 1957 to December 1959. f_0F2 and M3000 factor data for June, September, and December 1958 are used in an IBM 7090 simple linear analysis computer program. (The ionosonde stations used included Huancayo, Peru.)

The F2-3000 km-MUF is equal to the product of f_0F2 and the M3000 factor. The M3000 factor is related to h'F (the virtual height of reflection). f_0F2 and h'F both display a lunar tidal variation but not with the same phase. Martyn (1947), McNish and Gautier (1949), and Rastogi (1962) have all discussed lunar tidal variations in the F2 layer of the ionosphere. Matsushita (in press) reports that there is a 6 hour difference in the f_0F2 lunar variation (i.e., completely opposite phase) between middle latitudes and the magnetic equatorial zone. The time lag between the phases of h'F2 and f_0F2 is about 3 hours in middle latitudes and about 6 hours in the magnetic equatorial zone. He also concludes that usually the amplitude of the f_0F2 and $h_{max}F2$ lunar tides in local summer is larger than in local winter, and that the phase changes only slightly. It can be seen, in figure 1 and 2, that the comparisons of Washington, D.C., and Chimbote f_0F2 data and Washington, D.C., and Huancayo f_0F2 data give the lowest correlation coefficients in June 1958 and highest in December 1958.

Martyn (1947) stated that the major anomalies in the behavior of the F2 region of the ionosphere were due to the action of the solar atmospheric tide. He presented data showing the existence of large 12-hourly harmonics in maximum density of ionization (N_{max}) and the height at which N_{max} occurs (h_{max}). At the same time he indicated that it was difficult to isolate the sun's strong ionizing effect, with a 24 hour periodicity, but with appreciable 12-hourly harmonics.

An attempt was made to isolate the sun's ionizing effect in figures 9 and 10. In figure 9, for each hour of the day, the September 1958 monthly mean values of f_0F2 for Huancayo (12.0°S, 75.3°W) are subtracted from the September 1958 monthly mean values of f_0F2 for Panama (9.4°N, 79.9°W) and the results (δf_0F2) are plotted. The subsolar point on September 15th is about 3°N. Also in figure 9, for each hour of the day, the June 1958 monthly mean values of f_0F2 for Washington, D.C., (38.7°N, 77.1°W) are subtracted from the June 1958 monthly mean values of f_0F2 for Panama and the results (δf_0F2) are plotted. The subsolar point on

June 15th is about 23°N. For the June 1958 data, the stations, about equal distance north and south of the subsolar point, were chosen so that the maximum ion density from the sun's ionizing term (proportional to $\cos^{1/2}\chi$) would vary only slightly. For the September 1958 data, the northern station is about 6.4° from the subsolar point while the southern station is about 15° away. However, the $\cos^{1/2}\chi$ term is essentially the same for both stations. In figure 10, the same procedure is carried out for the F2-3000 km-MUF for the same months and stations. From figures 9 and 10, it can be seen that both f_0F2 and F2-3000 km-MUF tend to show a very marked semi-diurnal solar tidal influence.
Excerpt

ZACHARISEN, D. H. Some applications of the theory of using observations at ionosphere stations to estimate current values of ionospheric characteristics at other locations. IN: Semi-annual Report to Voice of America, NBS Rept. 8226, National Bureau of Standards, Boulder, Colo., 130 (July 1963).

This contribution presents some illustrative applications of the theory described in Contribution No. 4 of the previous semi-annual report (NBS Report 7696) and in Contribution No. 7 of this report. Use will be made of the results of studies of the correlation coefficients of f_0F2 and F2-3000 km-MUF for various pairs of stations presented in Contribution No. 6 in the NBS Report 7621 and Contribution No. 3 in NBS Report 7696.

For convenience, the above related contributions will be designated as follows:

A-I Contribution No. 6 in NBS Report 7621

A-II Contribution No. 3 in NBS Report 7696

B-I Contribution No. 4 in NBS Report 7696

B-II Contribution No. 7 in the present report (NBS Report 8226).

The theory deals with the problem of estimating the current value of an ionospheric parameter (e.g. critical frequency, or MUF) at a location L_0 where direct observations are not available, by utilizing observations of current values at other locations $L_1, L_2, \ldots L_n$. A knowledge of the variances at each location, including L_0, and of the covariance (or correlation coefficient) for each pair of locations is required. The correlation coefficients for f_0F2 and F2-3000 km-MUF and their variations with station pair separation distance, geographical location, season, and time of day were the subjects of A-I and A-II.

$$x_p = k_1x_1 + k_2x_2 + \ldots + k_nx_n = \sum_1^n k_ix_i \qquad (1)$$

where $x_1, x_2, \ldots, x_n$ are the observed departures from the means at $L_1, L_2, \ldots, L_n$ and the prediction coefficients $k_1, k_2, \ldots, k_n$ are determined from the condition that the mean square error of x_p shall be a minimum.
Excerpt

ZAGULYAYEVA, V. A. Lunar tidal variations of critical frequencies of the E layer. Geomagnetism and Aeronomy, Moscow. III, 766-767 (1963).

This article cites the results of computation of tides in f_0E for the stations Moscow, Tomsk, Irkutsk, but in the greatest detail for Ashkhabad. In general, the observations were for the period 1 January 1949 through 31 December 1956. Curves of the dependence of f_0E on side real time were derived for the entire period considered. Each hourly value was the result of averaging 889 values for Moscow, 883 values for Tomsk, 875 values for Irkutsk and 376 values for Ashkhabad. These curves are shown as Fig. 1. After being broken down in summer, winter and equinoctial categories, the curves were subjected to harmonic analysis. The semidiurnal harmonic could be determined reliably for Moscow and Ashkhabad, but not for Irkutsk or Tomsk. At the latter stations the tidal effect was smaller by a factor of 2 or more than for Moscow, despite the fact that all three stations are at almost the same latitude. $L(f_0E)$ increases from winter to summer, with an intermediate value at the equinox. The maximum sets in earlier in summer than at the equinox and earlier at the equinox than in the winter. At Moscow the tidal effect is very small during the winter, so that it is impossible to consider the derived amplitude and phase values to be completely reliable.
A

ZMUDA, A. J. Ionospheric electrostatic fields and the equatorial electrojet. J. Geophys. Res. 65, 2247-2253 (1960).

The electrostatic characteristics associated with the equatorial electrojet are investigated with the aid of a number of theoretical and experimental considerations. With regard to the peak electrojet current, an eastward component of electric force of magnitude 4×10^{-4} volt/meter drives a current of density 10^{-5} amp/meter^3. In the region of maximum current the ionosphere is electrically neutral, but the electric field is

created by an electrostatic charge distribution with an excess of electrons in the region east of the point with peak current and an excess of positive charges in the region to the west. The maximum of the difference in the number density of the negative and positive charges is 5×10^{-2} charge/meter^3 for the volume density, and 9×10^4 charge/meter^2 for the surface density on the lower boundary of the E layer. These number differences, which represent extremely small departures from electrical neutrality in the ionosphere, indicate the prime importance of a surface charge distribution in producing the ionospheric electrostatic field. The vertical component of the electrostatic force has a maximum value of 4×10^{-4} volt/meter but vanishes at the point containing the peak electrojet current.
A

ZMUDA, A. J. The mutual dependence of harmon c coefficients. (Abstract of) paper presented at the Forty-First Annual Meeting, American Geophysical Union, 27-30 April 1960, Washington, D. C. J. Geophys. Res. 65, 2534 (1960).

It is well known that the incomplete magnetic coverage imposes general limitations on the accuracy with which the harmonic coefficients may be determined: The harmonic coefficients are mutually dependent in that their values depend on the number of coefficients to be determined. The magnitude of this effect is treated using the results of a harmonic analysis of surface data. Also, a comparison is made between coefficients obtained from the series for the different components of the magnetic force.

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U.S. Army Electronics Command Fort Monmouth, New Jersey

13. ABSTRACT

A survey of the literature pertaining to the equatorial ionosphere, tropical radio communications, and related subjects is presented in bibliographical form. Authors' abstracts have been included whenever possible. The survey is intended to cover the period from the late 1920's and early 1930's through the early 1960's.

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14 KEY WORDS	LINK A		LINK B		LINK C	
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